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The terrestrial biota of Charcot Island, eastern Bellingshausen Sea, Antarctica: an example of extreme isolation

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Abstract: This paper documents the previously undescribed terrestrial fauna (mites, nematodes, tardigrades) and flora (liverworts, mosses and lichens) of Marion Nunataks, Charcot Island (69°45'S 075°15'W). Species diversity in all groups is low relative to other Maritime Antarctic sites, probably a twin function of very limited ice-free terrain and extreme isolation. The fauna and flora are wholly immigrant and, with the exceptions of two lichens (*Psilolechia lucida* and *Umbilicaria* aff. *thamnodes*), clearly derived from the Maritime Antarctic. The fauna is unique for the Maritime Antarctic in that it appears to contain neither predatory arthropods nor Collembola (springtails), which are otherwise ubiquitous and important members of the terrestrial fauna of the zone. The flora includes exceptional development of three mosses that are encountered only rarely at latitudes south of *c.* 65°S, *Brachythecium austrosalebrosum*, *Dicranoweisia crispula* and *Polytrichum piliferum*. The southern limit for several mosses and lichens has been extended. This small and isolated site is extremely vulnerable to accidental human-mediated introduction of both native Antarctic and alien biota.

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Key words: bryophytes, Charcot Island, geographical isolation, lichens, soil meiofauna and microarthropods

Introduction

Charcot Island lies at *c.* 70°S, 075°W in the eastern Bellingshausen Sea, *c.* 100 km west of Alexander Island (Fig. 1), to which it is connected by the decaying Wilkins Ice Shelf. It was discovered during the 1908–10 French Antarctic Expedition, led by Jean-Baptiste Charcot but, other than overflights and aerial reconnaissance, has been rarely visited (Headland 1989). Carboniferous fine-grained sedimentary sandstones and mudstones, and weakly metamorphic rocks of the LeMay Group, with a high proportion of quartz, plagioclase and feldspar, indicate a common geological origin with much of Alexander Island (Bell 1976, Burn 1984). A brief visit by British Antarctic Survey geologists in January 1995 (B. Storey, personal communication 1995) reported a significant stand of vegetation on a single coastal nunatak within Marion Nunataks, on the north coast of Charcot Island (69°45'S 075°15'W). The first, and only, biological collections made here during the 1997/8 and 1998/9 summers form the subject of this paper.

The majority of Charcot Island is covered by a smooth, gently-sloping permanent icecap. The only ice-free ground present is associated with Marion Nunataks on the island's north coast, and consists predominantly of near-vertical cliffs (Fig. 2). The island is extremely isolated relative to other known or potential ice-free biological sites on the south-western Antarctic Peninsula and Alexander Island (southern Maritime Antarctic) and the coast of Ellsworth Land (Continental Antarctic). The nearest described sites are at *c.* 300 km in Ablation Valley on the east coast of Alexander Island, or over 400 km distant at a range of coastal sites between Adelaide Island and the Terra Firma Islands in southern Marguerite Bay (Smith & Poncet 1987, Smith 1988, Convey & Smith 1997). Charcot Island is similarly remote from known but unstudied sites. Excepting steep rock faces high on inland mountains of Rothschild and Alexander islands, the nearest sites known to possess significant vegetation are at 150 km, a low peninsula west of the Havre Mountains (north-west Alexander Island), at 200 km, an isolated group of unsurveyed oceanic islets north of Alexander Island and, at over 400 km, in unsurveyed coastal areas of the Bryan and English coasts, Ellsworth Land.

No climatic data are available, but Charcot Island lies in the track of depressions approaching the Antarctic Peninsula from the west. Satellite imagery indicates that the island is predominantly covered by cloud, and may not become free from winter pack ice until late in the summer, if at all. The prevailing winds and/or oceanic currents may potentially assist the transport of colonizing organisms or propagules from coastal regions of the Continental Antarctic, south and west of Charcot Island. Given that both the microarthropod and meiofauna of the two biogeographical zones are distinct, with very little overlap (Pugh 1993, Andrássy 1998), the occurrence of such a colonization process should be clearly identifiable. Thus, the combination of position and typical weather patterns imply that Charcot Island may be in a critical location to identify the boundary between Continental and Maritime Antarctic biogeographical zones (*sensu* Smith 1984).

This paper presents zoological and botanical data obtained in three short visits during the 1997/8 and 1998/9 summers. Logistic access to this remote and very small site is extremely limited and difficult, and has allowed no possibility of more detailed studies. The data obtained are used to describe the biogeographical relationships of Charcot Island, and highlight the exceptional combination of invertebrate, bryophyte and lichen taxa found.

Methods

Marion Nunataks

Marion Nunataks overlook the mid-north coast of Charcot Island (Fig. 2). Most exposed ground consists of steep north-facing cliffs. A single nunatak (arrow in Fig. 2a) was visited via an aircraft landing on an ice field immediately to its south, on 22 December 1997 (RILS) and 20/21 January (PC) and 5 February 1999 (PC). Ice-free ground extends *c.* 200 m east–west by a maximum of 50 m north–south. Currently, this is the only site known to harbour an extensive terrestrial biota, though a smaller nunatak with similar summit topography is present *c.* 2 km farther west.

The nunatak studied includes three vegetated areas (Fig. 2b):

i) a small, gently-sloping ridge and plateau immediately north and east of the summit (*c.* 125 m a.s.l.), which rapidly steepens into north-facing cliffs,

ii) boulder and scree slopes on a convex, rapidly steepening slope above cliffs to the east of and below the summit plateau,

iii) a lower, gently-sloping terrace at the eastern end of the nunatak, again steepening to cliffs.

In both December 1997 and January 1999 the coast was adjoined by consolidated pack ice. In February 1999 the pack ice was more broken but still 9/10 extent. Water was freely available in all three areas on each visit, although an air temperature of -5°C on 20/21 January 1999 resulted in surface ice formation.

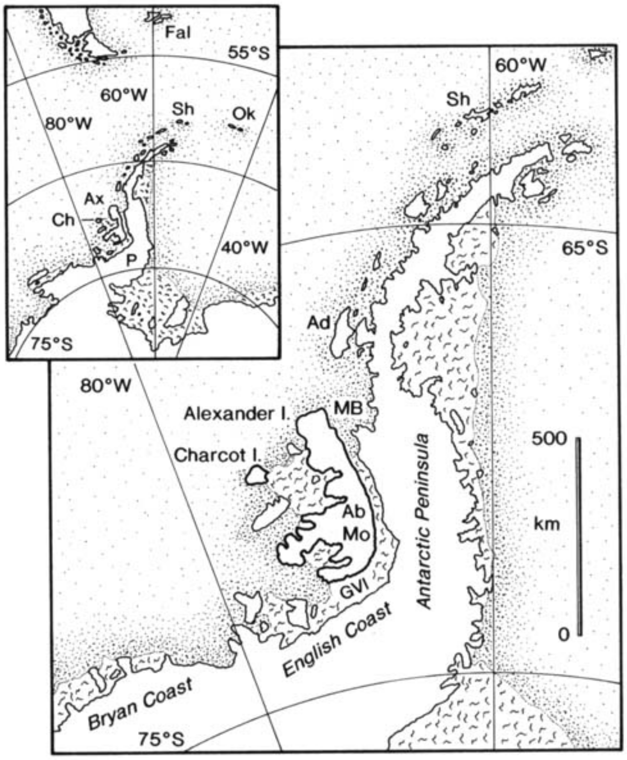

Fig. 1. Map of the Antarctic Peninsula region indicating the relationship of Charcot Island with other locations mentioned in the text.
Key: (main map) Ab = Ablation Valley, Ad = Adelaide Island, GVI = George VI Sound, MB = Marguerite Bay, Sh = South Shetland Islands, (inset) Ax = Alexander Island, Ch = Charcot Island, Fal = Falkland Islands, Ok = South Orkney Islands, P = Antarctic Peninsula.

Collections

On each visit representative vegetation ($n = 240$) and associated soil collections were made and returned by air within 12 h of collection to the British Antarctic Survey's Rothera research station. Practical safety considerations involved in movement around the site meant that a spatially structured sampling regime was not achievable; care was taken to ensure that all accessible vegetation, soil and rock habitats were examined.

Modified Tullgren ($n = 61$) or Baerman extractions ($n = 38$) were used on a proportion of the collections, in order to obtain qualitative samples for assessing species richness of micro-arthropods and meiofauna (Nematoda, Tardigrada), respectively. Samples used for extraction were maintained under ambient field temperatures (0–4°), with extractions completed within 2–10 days of the field visits. Substrates extracted included soil, moss clumps (*Andreaea* spp., *Bartramia patens*, *Bryum pseudotriquetrum*, *Brachythecium austrosalebrosum*, *Ceratodon purpureus*, *Dicranoweisia crispula*, *Grimmia reflexidens*, *Pohlia* spp., *Polytrichum piliferum*, *Syntrichia princeps*), foliose alga (*Prasiola crispa*) and various lichens. Large variation in the amount and structure of substrate available for extraction and the shallow depth of many substrates prevented valid quantitative comparisons. The maximum core size extracted (*c.* 10 cm diameter x 5 cm depth), from the turf-forming mosses *B. pseudotriquetrum*, *B. austrosalebrosum*, *C. purpureus* and *P. piliferum*, equates to 0.008 m^2. Additional collections of micro-arthropods were made by hand using a fine paintbrush, during examination of the underside and edges of stones embedded in soil and vegetation.

All vegetation samples were air-dried at Rothera research station before being returned to the UK. Bryophyte, lichen and invertebrate specimens are curated in the Biological Sciences Data and Resource Centre of the British Antarctic Survey, Cambridge, UK. Micro-arthropods were identified using appropriate keys (refs in Convey & Smith 1997), while nematodes were identified following Loof (1975) and Maslen

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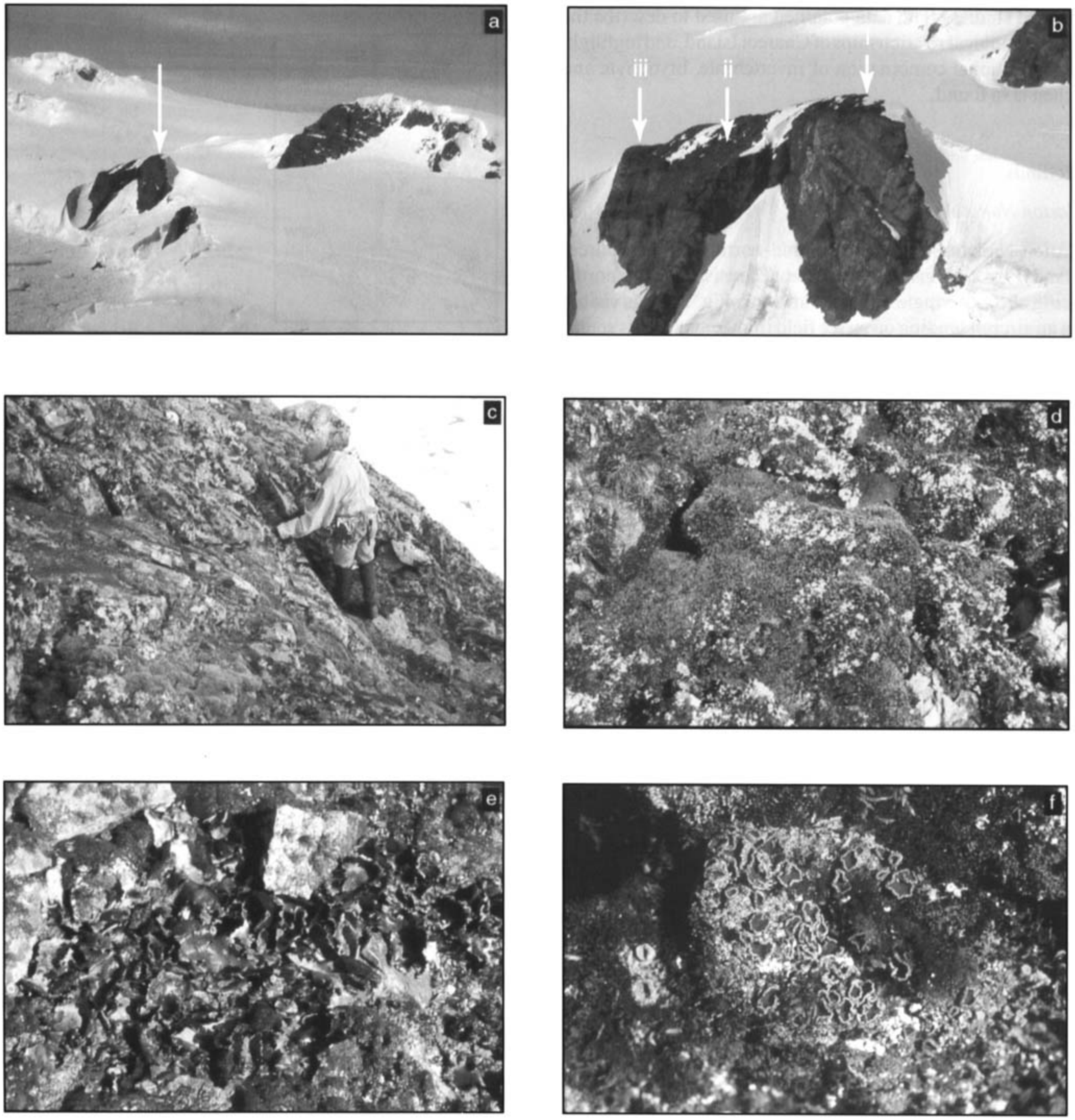

Fig. 2. a & b. Oblique aerial photographs of Marion Nunataks, Charcot Island, indicating the nunatak studied (see Methods), **c.** moss community dominated by *Pohlia* spp., *Polytrichum piliferum* and *Brachythecium austrosalebrosum*, **d.** turf of *Polytrichum piliferum* (*c.* 50 cm width), **e.** lush development of *Umbilicaria* spp. and *Andreaea* spp. associated with melt water, **f.** thallus of the lichen *Psoroma hypnorum* (*c.* 10 cm width).

(1979). Other groups have been examined by appropriate taxonomic specialists, with the plant and lichen taxonomic and distribution data presented here being extracted from the Antarctic Plant Database (Peat 1998).

Results

Terrestrial invertebrates

Seven species of Acari, seven Nematoda and four Tardigrada were present in extractions and other collections from Marion Nunataks (Table I). Neither acarine predators nor Collembola were recorded. Even allowing for the short duration of the

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Table I. Invertebrates recorded from Charcot Island, with notes on their wider distributions (arthropods after Pugh 1993, Block & Starý 1996, Convey & Smith 1997, Pugh & Convey in press, Convey unpublished data; nematodes after Loof 1975, Maslen 1979, Andrássy 1998; tardigrades after McInnes 1994).

Species	Wider distribution and notes
Acari, Prostigmata	
Nanorchestes nivalis sensu Judson	South Georgia, maritime Antarctic to south-east Alexander Island (Mars Oasis)
Eupodes minutus (Strandtmann)	sub- and maritime Antarctic to northern Marguerite Bay
Stereotydeus villosus (Trouessart)	maritime Antarctic to south-east Alexander Island (Coal Nunatak)
Acari, Cryptostigmata	
Alaskozetes antarcticus (Michael)	Falkland Islands, sub- and maritime Antarctic to southern Marguerite Bay
Halozetes belgicae (Michael)	sub- and maritime Antarctic to southern Marguerite Bay
Globoppia intermedia Hammer	South America, sub- and maritime Antarctic to northern Marguerite Bay (also unpublished new record of sub-species *G. intermedia longiseta* from Mars Oasis, south-east Alexander Island)
Magellozetes antarcticus (Michael)	South America, sub- and maritime Antarctic to south-east Alexander Island (Coal Nunatak)
Nematoda	
Plectus antarcticus de Man	maritime Antarctic to southern Marguerite Bay (Terra Firma Islands)*
Plectus parietinus Bastian	maritime Antarctic to central Alexander Island (Ablation Valley)
Eudorylaimus coniceps Loof (?)	maritime Antarctic to northern Marguerite Bay (Emperor Island)
Eudorylaimus spaulli Loof	maritime Antarctic to southern Marguerite Bay (Terra Firma Islands)
Mesodorylaimus imperator Loof	Marguerite Bay (Pourquois Pas and Terra Firma Islands)
Enchodelus signyensis Loof	maritime Antarctic to south-east Alexander Island (Mars Oasis)
Coomansus gerlachei de Man	maritime Antarctic to northern Marguerite Bay (Guébriant Island)
Tardigrada	
Echiniscus sp.	possibly new to science
Milnesium tardigradum Doyère	cosmopolitan, Falkland Islands, South Georgia, maritime, continental Antarctic
Macrobiotus sp. (? *M. furciger* J. Murray)	mainly Southern Hemisphere (also records from Europe and Asia), South Georgia, maritime Antarctic
Hypsibius cf. *dujardini* (Doyère)	cosmopolitan, South Georgia, maritime Antarctic

*note: Andrássy (1998) considers that this species is restricted to the maritime Antarctic, and refers previous continental Antarctic records to other *Plectus* spp.)

three sampling visits, we consider that it is extremely unlikely these two groups have been overlooked, given that they have been obtained reliably in similar extractions from all other maritime Antarctic sites examined by the authors, as well as being visually obvious and easy to locate *in situ* at all such sites.

All Acari recorded occur elsewhere in the maritime Antarctic, with distributions extending at least to Marguerite Bay (*c.* 68°S) and, for four species, to southern Alexander Island (*c.* 72°S). Most are also recorded from sub-Antarctic islands, with three extending to the Falkland Islands or southern South America. There were no continental Antarctic species. Numbers of mites obtained in extractions of turf-forming mosses were 100–350 individuals per core, equating to *c.* $1.2–4.4 \times 10^4$ m^{-2}. All nematodes identified are currently known only from the maritime Antarctic, with the southern limit for most being extended by this study. Three of the four tardigrades are also known from elsewhere in the maritime Antarctic, with two being cosmopolitan. The fourth is currently thought to be an undescribed species.

Bryophytes and higher plants

Seventeen bryophytes (16 mosses, one liverwort) were recorded (Table II). The grass, *Deschampsia antarctica* Desv., whose southern distribution limit in Marguerite Bay is close to the latitude of Charcot Island (Smith & Poncet 1987), was not present. All bryophytes are widely distributed Antarctic species, known from elsewhere in the Maritime or sub-Antarctic zones, with nine species also recorded from the Continental Antarctic. Only *Andreaea gainii* and *Schistidium antarctici* are endemic to the Antarctic, while four species are known from elsewhere in the Southern Hemisphere. Most (10/17 = 59%) have bipolar or cosmopolitan distributions.

The presence of several moss species (notably *Andreaea* spp., *Bartramia patens*, *Brachythecium austrosalebrosum*, *Dicranoweisia crispula and Polytrichum piliferum*) is unusual at such a high latitude. The abundance of *B. austrosalebrosum* is remarkable as it is a hydric species requiring a continuous supply of water. The Charcot Island population occurs mainly on wet rock slabs irrigated by trickling melt water from late snow patches, and allowing the development of luxuriant loose cushions *c.* 15 cm tall. The pleurocarpous *Hypnum revolutum* occurs occasionally in moist crevices and at the base of boulders. As elsewhere in the southern Antarctic Peninsula region, this species replaces *Sanionia uncinata* (Hedw.) Loeske which dominates wet habitats farther north. *Andreaea* spp., *D. crispula* and *Grimmia reflexidens* are frequent both on rock and gravelly soil, and all are abundantly fertile. *Dicranoweisia crispula* appears to be very scarce throughout the maritime Antarctic yet, like *Andreaea* spp., *B. austrosalebrosum* and *P. piliferum*, it achieves local dominance here. The liverwort *Cephaloziella varians* occurs infrequently amongst moss in moist habitats.

Table II. Mosses and liverworts recorded from Charcot Island, with notes on their wider distributions (see Ochyra 1998).

Species	Wider distribution
Liverwort	
Cephaloziella varians (Gott.) Steph.	South America (?), sub-, maritime, continental Antarctic
Mosses	
Andreaea gainii Card.	maritime, continental Antarctic (Eights Coast)
Andreaea regularis C. Muell.	southern South America, Tristan da Cunha, Falkland Islands, sub-, maritime, continental Antarctic (Eights Coast)
Bartramia patens Brid.	south temperate, South Atlantic islands, sub-, maritime Antarctic
Bryum argenteum Hedw.	cosmopolitan, maritime, continental Antarctic
Brachythecium austrosalebrosum (C. Muell.) Kindb.	south temperate, sub-, maritime Antarctic
Bryum pseudotriquetrum (Hedw.) Gaertn.	cosmopolitan, Falkland Islands, sub-, maritime, continental Antarctic
Ceratodon purpureus (Hedw.) Brid.	cosmopolitan, sub-, maritime, continental Antarctic
Dicranoweisia crispula (Hedw.) Milde	bipolar, alpine, Falkland Islands, South Georgia, maritime Antarctic
Grimmia reflexidens Mull. Hal.	bipolar, alpine, maritime, continental Antarctic
Hennediella heimii (Hedw.) Zand.	bipolar, temperate, Falkland Islands, sub-, maritime, continental Antarctic
Hypnum revolutum (Mitt.) Lindb.	bipolar, alpine, maritime Antarctic
Pohlia cruda (Hedw.) Lindb.	bipolar, sub-, maritime, continental Antarctic (Eights Coast)
Pohlia nutans (Hedw.) Lindb.	cosmopolitan, sub-, maritime, continental Antarctic
Polytrichum piliferum Hedw.	cosmopolitan, sub-, maritime Antarctic to Argentine Islands, isolated records from *c.* 67–72°S, Marguerite Bay, Bowman Coast and E of George VI Sound
Schistidium antarctici (Card.) L. Savic. & Smirn.	maritime, continental Antarctic
Syntrichia princeps (De Not.) Mitt.	bipolar, temperate, Falkland Islands, sub-, maritime, continental Antarctic

Polytrichastrum alpinum (Hedw.) G.L. Sm., relatively common in the northern Marguerite Bay area, is absent from Charcot Island. In comparable habitats it is replaced by *Polytrichum piliferum*, a species rare in the former area, forming shallow turfs of *c.* 10 cm depth and 0.5–2 m^2 extent. Although communities including this species are well developed within the sub-Antarctic, and there are records from coastal sites of the western Antarctic Peninsula to *c.* 65°S, its occurrence at more southerly latitudes is extremely disjunct, with only four localities known south of 67°S. In contrast to the coastal communities in which it is typically found in more northern sites, the high latitude records are mostly from higher altitude montane sites, while even the coastal community described here is found at *c.* 100 m a.s.l.

Lichens

Greater diversity was present amongst the lichens with 34 species, plus two further taxa currently identified only to genus (Table III). The identity of several additional crustose taxa remains uncertain. Again, the majority (21/34 = 62%) have bipolar or cosmopolitan distributions, with 7/34 species (= 21%) being Antarctic endemics. Only two species (*Psilolechia lucida* and *Umbilicaria* aff. *thamnodes*, the latter, if confirmed, being previously known only from the Himalayas) are previously unrecorded in the Antarctic. Two other species are restricted to the Maritime Antarctic, two to the Maritime and Continental zones and one, *Massalongia intricata*, is only known from Charcot Island and sub-Antarctic South Georgia (Øvstedal & Smith in press). The failure to record the widespread *Usnea antarctica* Du Rietz is surprising.

Numerous lichens are associated with the mosses, but the most widespread community is dominated by the lichens *Pseudephebe minuscula*, *Umbilicaria decussata*, *Usnea sphacelata* and various crustose taxa, and the mosses *Andreaea* spp., *D. crispula* and *P. piliferum*. Such communities occupy much of the dry, windswept stony plateau and ridge. In more hydric situations, in association with turves of *P. piliferum*, luxuriant colonies of *Cladonia* spp. and *Stereocaulon glabrum* are locally common. Melt channels on sloping rock slabs are lined with large thalli (up to 15 cm across) of *Umbilicaria antarctica*, and moist cushions and turves of moss are colonised by muscicolous lichens (notably *Massalongia* spp., *Pannaria hookeri*, *Psoroma* spp. and *Rinodina* sp.?). As with several of the mosses, Marion Nunataks represent the farthest south known occurrence for some lichens, including *Frutidella caesioatra*, *Massalongia* spp., *Ochrolechia frigida*, *Usnea aurantiaco-atra*, *U. trachycarpa*. The only bird perch boulder seen had meagre growths of *Caloplaca saxicola*, *Physcia dubia* and several undetermined crustose taxa.

Vertebrate influence

The site has little vertebrate influence. Four south polar skuas (*Catharacta maccormicki* Saunders) were seen during the 1997 visit, and five in 1999. In both seasons, a single nest was present on the moss turf of the lower eastern terrace. Although defending the nest site, which showed evidence of being used over several years, this pair had failed to produce any eggs by the February 1999 visit. Other birds noted and considered likely to breed in the area were small numbers of Antarctic terns (*Sterna vittata* Gmelin, both years), snow petrels (*Pagodroma nivea* (Forster), both years), Antarctic petrels (*Thalassoica antarctica* (Gmelin)), two in 1997) and Wilson's

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Table III. Lichens recorded from Charcot Island, with notes on wider specific distributions (see Øvstedal & Smith in press).

Species	wider distribution
Arthrorhaphis citrinella (Ach.) Poelt	bipolar, South Georgia, maritime Antarctic
Austrolecia antarctica Hertel	maritime Antarctic to central Alexander Island (Fossil Bluff)
Buellia sp.	
Caloplaca saxicola (Hoffm.) Nordin	bipolar, maritime, continental Antarctic
Candelariella vitellina (Hoffm.) Müll. Arg.	bipolar, South Georgia, maritime Antarctic
Cladonia cf. *chlorophaea* (Flørke *ex* Sommerf.) Sprengel	cosmopolitan, Falkland Islands, sub-, maritime Antarctic
Cladonia cf. *subulata* (L.) Weber *ex* Wigg.	bipolar, South Georgia, maritime Antarctic
Frutidella caesioatra (Schaer.) Kalb	bipolar, South Georgia, maritime Antarctic
Lecanora physciella (Darb.) Hertel	South Georgia, maritime, continental Antarctic
Lecidella protracta (Darb.) Hertel	Falkland Islands, South Georgia, maritime Antarctic
Lecidella siplei (C.W. Dodge & G.E. Baker) M. Inoue	maritime, continental Antarctic
Lepraria caesioalba (de Lesd.) Laundon	bipolar, South Georgia, maritime, continental Antarctic
Lepraria straminea Vain.	maritime Antarctic
Massalongia carnosa (Dicks.) Körb.	bipolar, South Georgia, maritime Antarctic
Massalongia intricata Øvstedal	South Georgia, Charcot Island
Mycobilimbia lobulata (Sommerf.) Hafellner	bipolar, maritime Antarctic
Ochrolechia frigida (Sw.) Lynge	bipolar, alpine, South Georgia, maritime Antarctic
Pannaria hookeri (Borrer *ex* Sm.) Nyl.	bipolar, South Georgia, maritime Antarctic
Physcia dubia (Hoffm.) Lettau	bipolar, South Georgia, maritime, continental Antarctic
Placynthiella icmalea (Ach.) Coppins & P. James	bipolar, southern maritime, continental Antarctic
Pseudephebe minuscula (Nyl. *ex* Arnold) Brodo & D. Hawksw.	bipolar, South Georgia, maritime, continental Antarctic
Pseudephebe pubescens (L.) Choisy	bipolar, alpine, New Zealand, southern South America, South Georgia, maritime Antarctic
Psilolechia lucida (Ach.) M. Choisy	bipolar, southern Chile, Tasmania, no other Antarctic records
Psoroma cinnamomeum Malme	southern South America, South Georgia, maritime Antarctic
Psoroma hypnorum (Vahl) Gray	bipolar, South Georgia, maritime Antarctic
Rhizocarpon disporum (Hepp.) Müll. Arg.	bipolar, maritime, continental Antarctic
Rhizocarpon geographicum (L.) DC.	cosmopolitan, South Georgia, maritime, continental Antarctic
Rhizoplaca aspidophora (Vain.) Redón	South Georgia, maritime Antarctic
Rinodina sp.	
Stereocaulon glabrum (Müll. Arg.) Vain.	southern South America, Tristan da Cunha, South Georgia, maritime Antarctic
Umbilicaria antarctica Frey & I.M. Lamb	maritime, continental Antarctic
Umbilicaria decussata (Vill.) Zahlbr.	cosmopolitan, maritime, continental Antarctic
Umbilicaria aff. *thamnodes* Hue	if confirmed, only known from Himalayas
Usnea aurantiaco-atra (Jacq.) Bory	southern South America, Falkland Islands, South Georgia, maritime Antarctic
Usnea sphacelata R. Br.	bipolar, alpine, maritime, continental Antarctic
Usnea trachycarpa (Stirton) Müll. Arg.	southern South America, Falkland Islands, sub- and maritime Antarctic

storm petrels (*Oceanites oceanicus* Kühl, both years).

Discussion

Both fauna and flora of Charcot Island comprise predominantly species already known from elsewhere in the Maritime Antarctic biogeographical zone, although this study refines their known distribution limits. There was no evidence of colonization by Continental Antarctic zone species, potentially encouraged by the island's position at the extreme south-west of the Maritime Antarctic and prevailing air and ocean circulations. The position and extent of the study site, and the shallow depth of vegetation and soil, suggest that it has only been exposed by retreating ice relatively recently (cf. glaciological models of ice-shelf extent and thickness in the southern Antarctic Peninsula region (Clapperton & Sugden 1982)). The cover of vegetation and size achieved by some lichens is suggestive of several centuries of exposure. Both fauna and flora are therefore likely to be immigrant. Although the biota is obviously typical of the Maritime Antarctic zone, community composition differs strikingly in detail from that found at other sites within the biome.

The apparent absence of Collembola within the arthropod community distinguishes Charcot Island from all other known Maritime Antarctic sites, contrasting directly with their importance elsewhere (e.g. Tilbrook 1967, Block 1982, 1984, Usher & Booth 1982, Usher & Edwards 1986, Convey & Smith 1997). This includes even isolated islands such as the South Sandwich archipelago (Convey *et al.* 2000) and Bouvetøya (Holdgate *et al.* 1968), and sites at more southerly latitudes on south-east Alexander Island (Convey & Smith 1997). The extremely isolated Peter I Øya (*c.* 68°S, 090°W) has a very limited fauna consisting only of *Halozetes belgicae* (Block & Starý 1996), with no Collembola (L. Sømme, personal communication 2000).

Extractions made in this study were not quantitative, yet the numbers of animals recovered suggest population densities comparable with those found in many other coastal Maritime

Antarctic sites, at least an order of magnitude greater than those usually found in Continental Antarctic sites, or on south-east Alexander Island at the southern limit of the Maritime Antarctic (cf. Convey & Smith 1997). The numerical contribution made by springtails to faunas elsewhere in the Maritime Antarctic appears to be replaced by smaller prostigmatid mites (*Nanorchestes nivalis* and, particularly, *Eupodes minutus*) on Charcot Island (although note that high densities of *E. minutus*, *c.* 16 000 m^{-2}, have been reported recently in much more diverse soil arthropod communities on sub-Antarctic Marion Island (Barendse 1999)).

The apparent absence of predatory taxa is also an exceptional element of the Charcot Island arthropod community, particularly given the arthropod population densities. This may again be a function of the recent exposure of the site, colonization by predators necessarily having to follow development of prey communities. In the Maritime Antarctic, absence of predatory Acari has been noted only at some sites around Mars Oasis and Fossil Bluff, south-east Alexander Island, while even here the prostigmatid predator *Rhagidia gerlachei* (Trouessart) is recorded from Ablation Valley (Convey & Smith 1997). Many continental faunas do not include predatory groups (Marshall & Pugh 1996).

The fauna is more closely related to typical Antarctic Peninsula sites than to those of the nearest studied sites on east and south-east Alexander Island, which are distinct from those of Marguerite Bay and farther north by virtue of including an endemic springtail, *Friesia topo* Greenslade (Greenslade 1995). The acarofauna of Charcot Island includes a different sub-species of *Globoppia intermedia* to that found in collections obtained from Mars Oasis, includes *Eupodes minutus* rather than the *E. parvus* Booth *et al.* recorded from Ablation Valley, and does not include Tydeidae (Table I; cf. Convey & Smith 1997).

All nematodes found on Charcot Island are species currently thought to be restricted to the Maritime Antarctic (Loof 1975, Maslen 1979, Andrássy 1998). Species diversity is lower than the nearest sites examined in any detail in Marguerite Bay (cf. Maslen 1979). Maslen's provisional recognition of several undeseribed species and the Continental Antarctic *Eudorylaimus antarcticus* (Steiner) in samples from Ablation Valley (Alexander Island) has been questioned by Andrássy (1998), as has his suggestion that Alexander Island forms the boundary between Continental and Maritime nematode faunas. It is therefore probable that further taxonomic examination of the present collections from Charcot Island will lead to additions to the island's fauna, particularly in the light of Andrássy's recent (1998) revision of the genus *Plectus*. In contrast, two of the four tardigrades found have cosmopolitan distributions, suggesting their dispersal mechanisms may have more in common with those of bryophytes and lichens (below) than other elements of the fauna.

As throughout the Maritime Antarctic, the nature of the bedrock and soil derived from it is a major determinant of the floristic composition of the plant communities. The shallow mineral soils are likely to experience frequent cryoturbation associated with freeze-thaw cycles, as reported for soils elsewhere in the Antarctic. In the absence of quantitative data, there is no evidence to suggest that this factor is of greater influence on colonization and establishment processes at Charcot Island than at other Maritime Antarctic sites. The mildly acidic meta-sedimentary rocks of Marion Nunataks have selected for a more calcifuge flora than that typical of the more calcareous sedimentary rocks and soils of eastern Alexander Island.

The bryophytes and lichens are typical of communities occurring in much of the Antarctic Peninsula region (Table II). A large proportion of both the bryophytes (59%) and lichens (62%) are species with bipolar or cosmopolitan distributions, with much smaller Antarctic endemic (18% and 21%, respectively) or Southern Hemisphere (23%, 15%) distributions (Tables II & III). The bryophyte figures show lower representation of Antarctic endemics, but are broadly similar to those for King George Island, South Shetland Islands (*c.* 62°S) where, although the area surveyed in detail was much greater, Ochyra (1998, table 1) gives *c.* 52% bipolar or cosmopolitan, *c.* 30% of species endemic to Antarctica (including sub-Antarctic) and 18% south temperate. However, Øvstedal & Smith (in press) consider that fewer (45%) Antarctic lichens have broadly bipolar or cosmopolitan distributions, with 31% endemic to Antarctica and 13% Southern Hemisphere (a further 10–11% show disjunct distributions). These figures indicate the importance of long-distance colonization processes in the origin of the Charcot Island bryophytes and lichens, with no possibility of input from sources closer than *c.* 150 km.

The absence of major soil invertebrate taxa, namely Collembola, or functional groups, particularly predatory Acari, indicate that Charcot Island is extremely vulnerable to accidental introductions mediated by human activity. Even without such assistance, the dominant Maritime Antarctic Collembola (*Cryptopygus* spp., *Friesia* spp.) are ubiquitous elsewhere in the region, being found even in very small areas of suitable habitat, including some likely to experience more extreme environmental conditions than Charcot Island. Several recent specific studies have highlighted the vulnerability of some Antarctic terrestrial ecosystems to aggressive invading aliens including Collembola (Greenslade 1995, Convey *et al.* 1999) and the potential problems caused by such introductions have been raised in the wider literature (*e.g.* Pugh 1994, Smith 1996, Chown *et al.* 1998), but little attention has been given to the transfer of "native" species. As visitors to this island will inevitably arrive from other locations within the Maritime zone, the potential for accidental transfer in soil or vegetation adhering to boots or clothing, rucksacks, etc. is great. Extreme caution is therefore required to avoid the transfer of native species between isolated populations within the Maritime Antarctic, highlighting an urgent need for strict control measures to be applied to all visitors to the site and others like it to conserve them for the future.

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