

The Falkland Islands were famously visited by Charles Darwin in 1832, but the legacy of his work is far from complete in relation to the conservation of the Island's biodiversity. The Territory is of geopolitical and strategic importance to the UK, and is subject to many environmental and development pressures (e.g. climate change, agriculture and fisheries, tourism expansion, oil and gas exploration). Environmental policy, planning and impact assessment in the Falklands require up-to-date biodiversity information referenced against the background of changing environmental conditions in the South Atlantic.

Many studies have been carried out on the iconic and charismatic birds and marine mammals of the Falkland Islands whereas the 'lower

plants' (mosses, liverworts, algae, lichens, fungi) have been neglected. Indeed, the Falkland Islands State of the Environment Report 2008 and the Biodiversity Strategy 2008–2018 highlight lower plants as the most critical knowledge gap and underline baseline surveying and taxonomic identification of lower plants, particularly bryophytes and lichens, as a high research priority. Due to the geoclimatic conditions of the South Atlantic, the diversity of lower plants in the Falkland Islands is far greater than the vascular flora (174 native flowering plants to date). Lower plants also play an important role in many of the Islands' ecosystems and are likely to be sensitive indicators of climate change.

Nearly 500 species of mosses have been recorded in the neighbouring biogeographical source-region of southern Patagonia and Tierra

Jeff Duckett,
Shaun Russell,
Rebecca Upson
and **Ray**
Tangney report
on a bryological
expedition to the
remote Falkland
Islands in January
2011.

Lower plants inventory and conservation in the Falkland Islands:

bryophyte reconnaissance and collecting expedition



del Fuego, and 125 species have been described from the much smaller and more remote island of South Georgia to the east (Ochyra *et al.*, 2008). 193 liverworts are known from the Brunswick Peninsula, a much smaller area in Southern Chile (Engel, 1978). By comparison, only 141 moss species plus 20 varieties (Matteri, 1986) and 130 liverworts and 1 hornwort (Engel, 1990) plus 6 subsequent additions (Wiggington, pers. com.) have so far been reported for the main Falkland Island group.

Knowledge of the liverworts rests heavily on John Engel whose 1,000 or so collections from 6 weeks field work in 1968 included all but 4

species previously recorded from the Islands plus 58 new additions. Earlier major collecting expeditions were by J.D. Hooker in 1842 (28 species), C. Skottsberg in 1902 (18 species), C. Skottsberg and G. Halle in 1908 (73 species) plus R.E. Longton and R.I. Lewis-Smith in 1965 (29 species), and R. Ochyra in 1980 (13 species) en route south to Antarctica. The fact that 44 species are at present known from but single collections or from just one of the two main islands (17 taxa on West Falkland only and 27 on East Falkland only with 48% of these restricted to the highest peak Mt Usborne) underlines the need for further exploration.

▽ (Left) Extensive stone runs typify many Falkland hillsides. (Top centre) Jeff Duckett, Rebecca Upson, Alan Orange and Ray Tangney outside the Falklands Conservation Headquarters, Port Stanley. (Top right) 'Jeffus prostratus' collecting *Lejeuneaceae*, *Lepicolea* and *Philonotis scabrifolia* on Mt Usborne. (Bottom) Rockhopper and Macaroni penguins north of White Rock House, West Falkland. J.G. Duckett (left, top centre, bottom); R. Tangney (top right)



For mosses, the situation is even worse: not having visited the islands, Matteri's flora (1986) was necessarily based on existing collections, including those gathered en passant by John Engel in 1968, and those of the Argentinians M. Rumboll and O. Kuhnemann, and Matteri considered that the previous surveys of mosses had been superficial. The fact that Matteri's flora lists no fewer than 21 endemics (cf only 4 liverworts) shows that there remains a need for further taxonomic studies. Overall, therefore, the floristic works to date indicate that there are many more bryophytes likely to be found on the Islands.

The expedition in January 2011

This expedition stemmed from a scoping visit to the Falklands by Shaun during February 2010. As a result, funding was obtained from the Shackleton Scholarships scheme, the Falkland Islands Government Environmental Studies Budget, the BBS and the John Cheek Trust. This enabled three lower planters to carry out a 3-week reconnaissance survey on the two main islands (East and West Falkland) of the moss (Ray), liverwort (Jeff) and lichen (Alan Orange, National Museum of Wales) communities as a prelude to what we hope will be an extended project funded by the Defra Darwin initiative. This project will not only form the foundation for long-term environmental monitoring, management and conservation of the bryophytes of the Falklands, but will also assist the UK Government and its Overseas Territories to meet commitments under the international Convention on Biological Diversity.

Consequent on Shaun's scoping visit in 2010, which established all the necessary contacts and infrastructure (accommodation, transport and laboratory facilities), plus rigorous preplanning of our itinerary using Rebecca's local knowledge,

Alan, Jeff and Ray were able to spend no fewer than 19 of their 21 days on the Islands doing field work; the other 2 days were devoted to processing specimens and running two workshops. Ray made by far the most extensive moss collection from the Islands, whilst Jeff's liverworts included over 95% of the species seen by John Engel plus several new ones. Alan collected approximately 880 lichen specimens, which were shipped back to the National Museum of Wales in Cardiff, in 12 boxes weighing many many kilos in early March 2011. In addition to the approximately 1,800 herbarium specimens of Falkland Islands lower plants, the excellent microscope facilities at our home base in the Falklands Conservation Headquarters in Port Stanley enabled the preparation of dozens of specimens for future molecular analyses and ultrastructural studies. However, lest we get carried away by our success it should be noted that the expedition had its downsides. No matter how hard you try you never find everything when time is limited: etched on Ray's memory is his failure to find *Oedipodium griffithianum* and *Fissidens rigidulus*, the only member of the genus recorded from the Islands, whilst Jeff's two major lacunae were *Radula helix* and *Schistochila subantarctica*, collected once and twice, respectively, by Engel in 1968 (Engel, 1990). We also feel it is only fair to point out the other hazards and possible setbacks for aspiring bryologists on the Falklands. Fenced-off minefields, dating from the Falklands war, are frustrating no-go areas; with grazing excluded the bryophytes within these always look particularly vigorous. Bryology on the Falklands requires much off-road driving through bogs and, like many before us, we (or more specifically Jeff, who was driving), got our Land Rover well and truly 'bogged'. The 6½ mile walk to get help from the proprietor of the Howard Lodge, West Falklands, was fortunately after we had finished



△ Hazards in the Falkland Islands. (Top) Minefields, a legacy of the war with Argentina. (Middle) Our bogged down Land Rover. (Bottom) The camera case thief – a striated caracara. J.G. Duckett

our collecting for the day. He kindly provided after-dinner entertainment for all his guests by pulling us out and we were back in business after breakfast the next day. Our fame quickly spread as thereafter we were addressed as ‘the mossers who got bogged’. It should also be mentioned that Jeff had his camera case stolen by a striated caracara whilst photographing *Megaceros fuegiensis*.

A further factor contributing to the comprehensive nature of the 2011 bryophyte collections was the compilation, prior to the visit, of illustrations of all the bryophytes recorded from the Islands. This proved easier for the mosses with around 43 species in common to the British Isles than for the liverworts with only six species in common (*Adelanthus lindenbergianus*, *Barbilophozia hatcheri*, *Lophocolea bispinosa*, *L. semiteres*, *Metzgeria leptoneura* and *M. violacea*). Though the 1990 Engel’s flora has excellent descriptions and keys, it contains just four illustrations and drawings are absent from Matteri’s flora. After many days work in the NHM library accessing some particularly obscure sources, e.g. Carrington & Pearson (1887), DeNotaris (1857), Evans (1930), Hässel de Menéndez (1972), Massalongo (1885) and Stephani (1911), Jeff copied illustrations of all but 14 of the liverworts. None exists for the outstanding species. Copies of this invaluable resource are now available in the Falklands Conservation offices in Port Stanley.

Though deficient in illustrations, Engel’s and Matteri’s floras do provide typical phytogeographic analyses and invaluable background information. The highest ‘mountains’ are Mt Adam, 750 m, on West Falkland and Mt Osborne, 705 m, on East Falkland. The geology mainly comprises Devonian sandstones and quartzites, upper Carboniferous-Permo-Triassic sediments and lower Cretaceous dolerite intrusions. Undoubtedly, the most striking feature of the Falklands landscape, which impressed Darwin



△ Top and middle rows. Typical grassland and saxicolous mosses. (Top left) The Antarctic species *Chorisodontium aciphyllum*. (Top right) The highly falcate endemic *Dicranoloma billardieri* var. *compactum*. (Middle left) *Racomitrium lamprocarpum*. (Middle right) *Racomitrium crispipilum*.
 △ Bottom row *Noteroclada confluens* (left) and *Megaceros fuegiensis* (right), a liverwort and hornwort typical of flushes across the Falklands. J.G. Duckett

Cryoturbation

– movement of soils and rocks by repeated freeze–thaw

in 1832, are extensive stone runs produced by ice age cryoturbation on a grand scale. The only natural calcareous substrates are sand dunes, which yielded *Aneura*, a genus new to the Islands, and bones. Extensive fertilization of pastures with calcareous red algae has produced a bryophyte desert dominated by *Holcus*. Given their location, annual rainfall on the Falklands is surprisingly low and rather uniform, varying from 399 mm at North Arm in the south, to 609 mm at Port Stanley, and a maximum of 646 mm at Port Howard. Frequent high winds, cloudy skies and poor soils probably contribute to the absence of native trees.

Findings and conclusions

Though the identification of all our collections remains ‘work in progress’, we are already able to draw some major and sometimes surprising conclusions from our visit and highlight some of our new discoveries.

Previous ideas that the richest areas bryologically, albeit based in a large part on single collections, are near the summits of Mt Adam and Mt Osborne and that altitude is the principal determinant of bryophyte distributions on the Falklands (Engel, 1990) have been overturned as our expedition found many taxa previously seen only near the mountain tops, and typical of high altitudes elsewhere in the world, close to sea level on the Falklands. The only species we found restricted to the windswept summit of Mt Maria (West Falkland, 658 m) and only known previously from a similar location on Mt Adam, was the giant polytrichalean species *Dendoligotrichum squamosum*. Unlike its dendroid habit elsewhere in the world, on the Falklands the ‘trunks’ are buried in the soil with only the terminal crowns of branches above the surface.

Highly degraded landscapes across the Falklands point to sheep grazing as more important than altitude in determining bryophyte distributions. Even by British standards, there was a heavy stocking rate of sheep in many parts of the Falklands, and by far the most diverse bryophyte communities are where grazing has been reduced by fencing (e.g. on the upper slopes of Mt Osborne) or where sheep cannot reach. Thus stone runs and rocky outcrops provide a variety of bryophyte-rich niches and here we see the development of communities closely resembling the mixed hepatic mats of the northern hemisphere (Hodd & Sheehy Skeffington, 2011) with *Adelanthus lindenbergianus* and *Barbilophozia hatcheri* two species common to both growing together with a southern hemisphere mixture of Schistochilaceae, *Adelanthus*, *Balantiopsis*, *Blepharidophyllum*, *Cryptochila*, *Gackstroemia*, *Lepicolea*, *Plagiochila* and numerous members of the Lepidoziaceae. We made the first collections of *Diplophyllum acutilobum*, *Metzgeria violacea* and *Pachyschistochila splachmophylla* from these communities on East Falkland. Also frequent is *Conostomum pentastichum*, previously known only from the summits of Mts Adam and Osborne, together with a second species, *Conostomum magellanicum*, new to the Islands. Whereas neither produce sporophytes in the Antarctic (Ochyra *et al.*, 2008), these are common on both species in the Falklands. Our discovery of *Rhacocarpus purpurascens* in the same habitat on Mt Maria confirmed Cardot’s (1908) listing for the Islands, but without a supporting herbarium specimen.

More tolerant of grazing are *Breutelia* and *Racomitrium*, and numerous members of the Dicranaceae with at least nine *Dicranoloma* species and varieties and rampant *Campylopus introflexus* which is particularly abundant around penguin colonies along the coasts.

Rocky outcrops support a range of *Andreaea* and *Racomitrium* species and, in the absence of native trees, *Frullania* and Lejeuneaceae are restricted to rock crevices and underhangs. Numerous taxonomically taxing little black liverworts include members of the genera *Cephaloziella*, *Herzogobryum*, *Pachyglossa* and *Pigafettoa*, but neither *Marsupella* nor *Scapania*, both known from Antarctica, have been seen on the Falklands (Bednarek-Ochyra *et al.*, 2000).

Given the low rainfall, we were not only surprised to find hepatic mat communities, but also an estimated 70–80% of the bryophyte biomass on the Falklands is composed of liverworts. Streams and stream sides in particular are liverwort-dominated with *Chiloscyphus* and *Clasmatocolea* species plus smaller quantities of *Drepanocladus* and *Blindia* in the water, and the simple thalloid *Jensenia* along the silty margins. The two *Conostomum* species are also frequent along stream banks down to sea level, whilst *Atrichopsis compressa*, an unusual polytrichalean

genus lacking dorsal leaf lamellae, is typical of the silty boulders in the streams across the Islands. Previously it was known from but a single locality on West Falkland. At least three *Notoligotrichum* species are characteristic of otherwise bare vertical banks.

As in Britain, flushed areas are dominated by *Calliergon*, *Brachythecium*, *Bryum*, *Philonotis*, *Pohlia* and the Falklands equivalent of *Pellia*, *Noteroclada confluens* (Fossombroniaceae), with smaller quantities of *Megaceros fuegiensis*. We found this hornwort much more frequently than Engel across both the main Islands. In contrast to the huge bogs in Tierra del Fuego, the four recorded *Sphagnum* species only form limited patches on the Falklands. The presence of mature sporophytes at the time of our visit in high summer was, as might have been predicted, exactly 6 months out of synchrony with the northern hemisphere.

Sporophyte production by Falkland bryophytes appears to be highly seasonal. The fact we saw

▽ (Below) Typical Falkland streams are dominated by liverworts, particularly *Chiloscyphus* spp. with mosses mainly confined to boulders at or above the water level. (Opposite bottom left) *Blindia torrentium*. (Opposite bottom right) *Atrichopsis compressa*. J.G. Duckett





△ (Above) Striking Falklands liverworts. (Top left) *Marchantia berteroana* the only native complex thalloid liverwort. (Top right) *Jensenia (Pallavicinia) xiphoides*. (Bottom left) *Lepicolea ochroleuca*. (Bottom right) *Pachyschistochila leucophylla*. J.G. Duckett





◁ Some interesting mosses. (Top left) *Dendroligotrichum squamosum*. (Top right) *Rhacocarpus purpurascens*. (Bottom left) *Conostomum magellanicum* (new to the Islands) growing with *Balantiopsis*. (Bottom right) Undescribed species growing on shipwreck timber dating from the 1920s. J.G. Duckett

very few bryophytes with young sporophytes at the height of the Falklands summer suggests that spring expeditions will be optimal for gaining the first insights into reproductive cycles on the islands and the possible discovery of more spring ephemerals. The latter proved to be the case for the 2006 expedition to south Chile which resulted in several mosses new to South America, including the bipolar moss *Pterygoneurum ovatum* (Matcham *et al.*, 2007; Ochyra *et al.*, 2008). It is therefore of particular interest that in the Falklands spring of 2010 Rebecca found *Pterygoneurum ovatum* new to the Falklands on offshore New Island where sheep grazing is absent. Future spring visits to New Island and other offshore islands where sheep are absent could well reap rich rewards bryologically.

Old whale bones are a peculiarly south Atlantic bryophyte habitat. These support a range of mosses, particularly *Syntrichia* species, including *S. papillosa* and *S. subpapillosa*, the

only two bryophytes of common occurrence as epiphytes on planted trees (*Nothofagus*, *Populus*, *Salix*, *Sambucus*, *Ulex*) on the Falklands. We also found *Tetraplodon mnioides*, the first record for the Splachnaceae, on the carcass of a sheep that had failed to traverse on a stone run on Mt Usborne. On the subject of unusual habitats, another bizarre discovery was an undescribed species of *Grimmia* (?) growing on timbers from a shipwreck dating from the 1920s.

The only complex thalloid liverwort native to the Falklands is *Marchantia berteriana*. This forms extensive and presumably perennial patches, sometimes several metres in diameter at frequent locations from sea level to the mountain tops. Whereas the vast majority of John Engel's fertile *Marchantia berteriana* collections were female, as appears to be the norm in *Marchantia* (Garcia-Ramos *et al.*, 2007; Groen *et al.*, 2010) we found males and females growing side by side in approximately equal frequency.



◁ (Top row) *Tetraplodon mnioides*, the first member of the Splachnaceae found in the Falklands. (Bottom) Whale bones support several *Syntrichia* species, including *S. papillosa* and *S. subpapillosa* (new to the Islands), better known as epiphytes elsewhere in the world. J.G. Duckett

Many cosmopolitan weedy bryophytes are rare or absent from the Falklands, and the two *Lophocolea* species (*L. bispinosa*, *L. semiteres*) introduced into Britain are native to the Islands. We were therefore surprised to discover two newly introduced liverworts, *Lunularia cruciata* and *Marchantia polymorpha* subsp. *ruderalis*, and two introduced mosses, *Hyophila involuta* and *Bryum dichotomum*, in the plant nursery at Port Stanley. *Marchantia polymorpha* is also an introduction associated with human activity in Antarctica (Bednarek-Ochyra *et al.*, 2000). The fact that the Port Stanley *Marchantia* comprised male plants only further attests to its recent arrival from either a single spore or gemma. We suggest that measures be put in place to confine this species to the plant nursery and minimize the risk of introducing the opposite sex to prevent its spread, particularly onto nutrient-rich soils around bird-nesting colonies to the possible detriment of the native bryophyte flora.

Assuming funding applications are successful, the clear priorities for future expeditions to the Falklands are the identification and mapping of the best hepatic mat communities and streams for both their conservation and long-term monitoring of the impacts of climate change, plus sampling of the smaller offshore islands where grazing is much reduced or absent, and sampling for ephemerals in the spring months. Though two centuries of grazing has badly damaged the natural bryophyte communities of the Falklands, providing that appropriate measures are now taken, there's no reason to expect any sheep-derived extinctions in the future. On the contrary, given the dedication and commitment of Falklands Conservation and good local support for and understanding of the Islands' conservation priorities, we are optimistic that bryophytes will continue to thrive and provide important subjects for future research on carbon cycling and climate change impacts in the far southern hemisphere.

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