Inventory and conservation of the bryoflora of south-western Patagonia

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Under the 'Darwin Initiative for the Conservation of Biodiversity' the UK Government's Department for Environment, Food and Rural Affairs funded a three year project during 2004-2007 to promote the conservation of the bryophyte flora of the southernmost province of Chile. This global bryophyte hotspot is currently threatened by logging, gravel and peat extraction, fish farming and expanding tourism interests (Russell 2006). The programme included collaboration with Chilean biologists to collect and to catalogue the bryoflora, set up a cryptogamic laboratory to house a herbarium and a library of relevant identification manuals and culturing facilities, and to raise awareness of the global importance of the unique and diverse bryoflora.

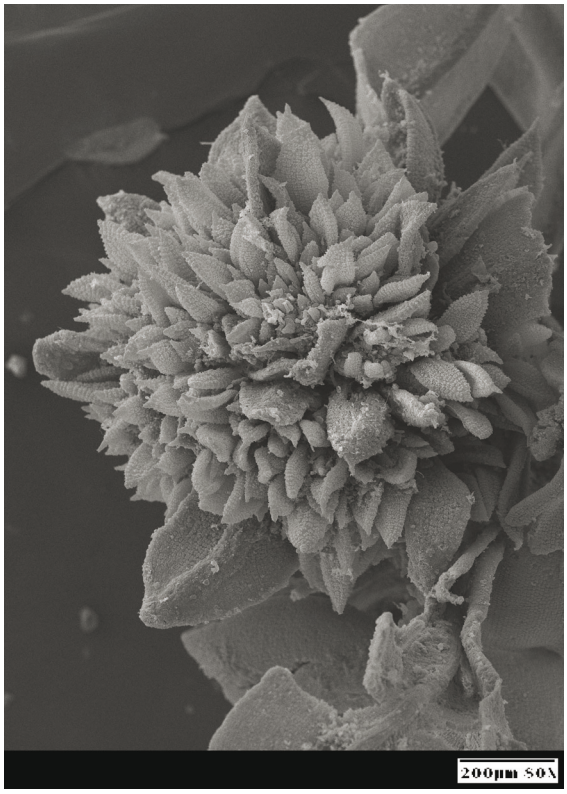

Figure 1. SEM of *Syntrichia laevipila*. Photo: Jeff G. Duckett.

The first year of the project saw the establishment of the laboratory complete with electricity, water and central heating from an old ship container at the Universidad de Magellanes in Punta Arenas (UMAG) and a two week expedition in a king and queen crab mother ship in the southern channels of Tierra del Fuego, including the Beagle Channel. A multidisciplinary team of 10 scientists

from UK, Chile, USA and Germany braved the southern ocean with waves of up to 4m (we have promised not to divulge the names of the 3 who were seasick) to collect over 4000 specimens from over 30 localities. Other activities included training of 16 Chileans in the field and various lectures promoting the 'Miniature Forests of Cape Horn' (Goffinet *et al.* 2006) and 'Tourism with a Handlens'.

Since the 2005 expedition, work on the collections has resulted in the discovery of many dramatic range extensions whilst axenic culturing has produced new insights into the importance of protomemal features in moss systematics and exciting developments in understanding the evolution of liverwort – fungus symbioses (Ligrone *et al.* 2007; Pressel *et al.* 2007a,b).

The final major activity in the project was a visit to Patagonia by Jeff Duckett and Howard Matcham in August and September 2006. The objectives were to catch up on progress with the bryophyte cultures, to return specimens from the previous expedition to the herbarium, to add comprehensive new collections from local sites, to continue training Chilean botanists and develop new research projects. A final goal was to explore the drier parts of Patagonia, previously unexplored bryologically in the early Chilean spring, in the hope of finding ephemerals new to the region. The discovery of *Acaulon* and *Crossidium*, both genera new to Chile during a stroll along the mouth of the Rio de las Minas on our first evening in Punta Arenas was a strong portent of good things to follow.

Figure 2. Degraded *Sphagnum magellanicum* bog. Photo: Jeff G. Duckett.

Figure 3. Degraded *Nothofagus* forest. Photo: Jeff G. Duckett.

During the visit we provided almost daily instruction in the field on bryophyte conservation and identification. Most of the specimens were identified to species level using the resources in the cyrptogamic laboratory (Engel 1978; Buck 2002; Smith 2004) and immediately deposited in the local herbarium. Those that needed further study are currently being identified by HWM using the collections at the Natural History Museum with the assistance of Len Ellis, the Curator of Bryophytes.

Activities in and around the laboratory in Punta Arenas included identification of the 65 species of mosses that are now in culture and close examination of the epiphytes on the introduced *Salix* trees nearby. These included the South American endemic *Syntrichia subpapillosa*, similar to *S. papillosa* in having adaxial leaf gemmae over the

Figure 4. *Megaceros fuegiensis*. Photo: Jeff G. Duckett.

costa but differing in that the basal part of the leaf is bordered. We also discovered that *S. subpapillosa* possesses rhizoidal gemmae similar to those found on the adaxial leaf surface. Despite an extensive literature search we could find no report of these in *S. papillosa* nor could we find them in our own herbarium specimens from the Northern hemisphere. Associates of *S. subpapillosa* were colonies of *Orthotrichum assimile* with extensive mats of gemmiferous protonemata like those often found in the Northern hemisphere in *O. affine*, *O. diaphanum* and *S. laevipila*, the latter moss found new to Chile from these willows. Fig. 1 is a scanning electron micrograph illustrating a typical gemmiferous shoot of the latter. Another species common as an epiphyte and on rotting wood and looking familiar to British bryologists was *Orthodontium australe.* Although recently synonymised with *O. lineare* it consistently differs in having a dorsal stereid band in the costa eight cells deep compared with a stereid band in *O. lineare* consistently four cells in depth. Its protonemal gemmae also differ from those of *O. lineare* (Duckett *et al.* 1991). The commonest liverwort growing alongside these mosses was *Metzgeria decipiens*, a species producing gemmae from the thallus margins like *M . temperata*.

Our first major excursion was south from Punta Arenas by minibus, with 16 Chileans and the American beever expert Chris Anderson who did sterling work as a translator, along the east coast of the Brunswick Penisula to explore remnants of the native *Nothofagus* forests comprising the evergreen *N. betuloides*, and deciduous *N. pumilio* and *N. antarctica* with *Drimys winteri* a frequent associate. All three *Nothofagus* species supported an extensive epiphyte community of lichens and bryophytes with, among the latter, several Orthotrichaceae including *Ulota magellanica* (mainly on trunks) and *Orthotrichum compactum* and *O. elegantulum* prominent on twigs. Leaning trunks supported swelling mats of *Bryum capillare, Leptostomum menziesii, Lepyrodon lagurus, Ptychomnion cygnisetum* and *Syntrichia andersonii*; the latter also grew abundantly on the forest floor. The primary colonist of rotting logs was *Roivainenia jacquinotii* (Lophoziaceae) followed by several members of the Lepidoziaceae, *Adelanthus lindenbergianus* and the spectacular *Gackstroemia magellanica* (Lepidolaenaceae). Large rock outcrops in the forest were frequented by the hepatics *Jamesoniella colorata*, *Cryptochila grandiflora, Lethocolea radicosa* and *Herzogobryum erosum*, and the mosses *Bucklandiella didyma* and *Hypnum cupressiforme* var. *mossmanianum.* This last and most appropriately-named taxon clearly looked to us like *H. cupressiforme* but was at the same time not an exact match to anything we had seen previously in the northern hemisphere. The most abundant species' on the forest floor were *Acrocladium auriculatum, Bartramia halleriana, B. patens* var. *robusta, Dicranoloma chilense, Goniobryum subbasilare* and *Pyrrhobryum mnioides,* the last two species in the Rhizogoniaceae, both species of *Dendroligotrichum* and, in wetter areas, sheets of *Megaceros fuegiensis*. Indeed a unique feature of the southern Chilean forests is the abundance of this hornwort and *M. endiviaefolius*. Dr Martin Carmona Ortiz from the University of Chile is currently investigating the role of nitrogen-fixation by the cyanobacteria in these hornworts in the nutrient

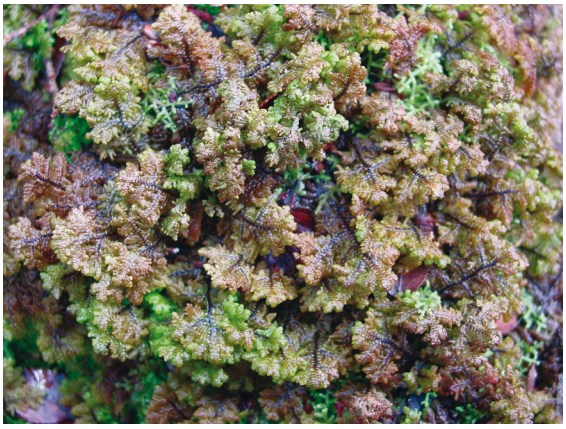

Figure 5. *Gackstroemia magellanica*. Photo: Jeff G. Duckett.

economy of the *Nothofagus* forests. Our visit conveniently provided him with specimens of other thalloid liverworts that contain gram-positive bacteria within the glomeromycote fungi inside their thalli (Ligrone *et al.* 2007), to investigate whether these also fix nitrogen. By far the most spectacular member of the Metzgeriidae, that occupies similar niches to northern hemisphere *Pellia epiphylla,* was *Noteroclada confluens*. With its myriad of setae up to 20cm in length this is one of the wonders of early spring in Chile rarely experienced by northern hemisphere bryologists.

The rocky shoreline at Fuerte Bulnes, 60km south of Punta Arenas, provided the Chilean students with an assemblage of very different species. These included *Dicranella hookeri, Hennediella antarctica, Muelleriella crassifolia* (Orthotrichaceae), *Pseudocrossidium crinitum, Schistidium* spp., including *S. falcatum* which, as its name suggests, has markedly falcate leaves, *Syntrichia andersonii,* and *Syntrichia pygmaea.* The last species, which has a markedly propaguliferous leaf apex, was initially identified as *Sarconeurum glaciale*, which shares this character. However, material sent to Ryzard Ochyra has been identified as the former, which we subsequently found in a variety of habitats including a sandstone escarpment and on a boulder on a basalt plug, where it was associated with *Syntrichia geheebiaeopsis*, another very local moss species which was found new to Chile on the 2005 expedition.

The final stop on this memorable day was when Jeff's ululations brought the minibus to a screaming halt as we passed a dripping roadside bank. This was covered with *Anthoceros* cf. *punctatus* (Engel 1978) and an undescribed *Phaeoceros* species.

Midway through our visit we made a 3 day trip north to the southern end of the Torres del Paine National Park with accomodation kindly provided by the university's field station at Puerto Natales. Frequent stops along the way to examine ungrazed roadside cuttings and gravelly banks produced *Aloina brevirostris* and *Pterygoneurum ovatum*, both species new to Chile and to South America. Cattle and sheep-grazed areas produced nothing of note and the margins of shallow lakes, again heavily cattle-poached, were similarly barren save for *Ceratodon* and *Bryum argenteum*. A particular target *en route* to Puerto Natales was the basalt plug El Morro, jutting through the otherwise featureless

Figure 6. *Neomeesia paludella*. Photo: Jeff G. Duckett.

Figure 7. *Noteroclada confluens*. Photo: Jeff G. Duckett.

landscape of the Patagonian steppe (Howard however, did, from time to time, get excited by the birds including the flightless rhea or nando and flocks of the spectacular Black-faced Ibis *Theristicus melanopis* flying low overhead. Partly migratory, this latter bird became a constant companion for the remainder of our trip). The lower slopes were strewn with boulders of varying size where a bryophyte seemingly familiar to us dominated the scene. This proved to be vast quantities of *Orthotrichum rupestre* associated with *Racomitrium* species and on a single boulder another familiar moss *Grimmia orbicularis.* It wasn't until we arrived back in the UK that it became apparent that this species was new to Latin America. This site also provided new localities for members of the Lophoziaceae including *Lophozia crispata* and *Barbilophozia hatcheri*. Most interesting was the discovery of a *Riccia* cf. *sorocarpa* much further south in the world than any previous reords for the Ricciaceae and the first record of *Reboulia hemispherica* from mainland Patagonia. These two finds doubled the number of marchantialean species previously known from Patagonia (*Marchantia berteroana* and *M. polymorpha* in Engel 1978).

North of Puerto Natales we explored sandstone cliffs near Tres Pasos in the hope of finding bryophytes like those occupying similar habitats in the Drakensberg of South Africa (Hodgetts *et al.* 1999) but with the Andean Condor (*Vultur gryphus*) replacing the Lammergeier (*Gypaetus barbatus*) overhead. The Condors were magnificent but the bryophytes less so apart from *Vittia pachyloma* in a stream. Conglomerate rocks in the vicinity of a local tourist attraction, the Milodon Cave, were however, covered with dense cushions of mosses including *Grimmia humilis* associated with *G. trichophylla, Hennediella densifolia, Orthotrichum rupestre, Pseudocrossidium crinitum, Racomitrium* species, *Syntrichia* species and the lichen *Usnea trachycarpa*. The driest part of the steppe to the north of Tres Pasos, where only lighly grazed, was dominated by dense stands of the shrub *Juniella tridens* (Verbenaceae). As expected, the ground beneath was dominated by 'mosses of harsh environments' (Zander, 1993), the Pottiaceae, including, depending on ones interpretation of the *Syntrihcia princeps* complex, putative *S. princeps, S. antarctica* and *S. magellanica* in abundance, associated with *Pseudocrossidium crinitum* and an unidentified *Bryum.*

The Torres del Paine is one of the world's premier tourist attractions. What 99% of tourists do not appreciate is that below the spectacular jagged peaks is a landscape completely devastated by overgrazing and fires. Needless to say with this prior biological knowledge we found the skeletal remains of *Nothofagus* forests burned over 70 years ago profoundly depressing. However, at the northmost point of our Patagonian journey we found, at Rio Vientisquero, an untouched glade of *N. betuloides* with streams and dripping rocks burst-

ing with bryophytes including *Fissidens rigidulus*, the only species in the genus seen throughout the entire trip, and a magnificent *Thamnobryum*, a genus only known previously in Chile from Juan Fernandez (Robinson Crusoe) Island.

One further final semi-desert excursion was to the national park at Pali Ake, an area of extinct volcanoes in NE Patagonia near the Argentinean border where guanaco (the steppe camellid), nandos, foxes and a skunk failed to distract us from making comprehensive collections of the Grimmiales and admiring large cushions of the recently described *Racomitrium patagonicum* (Bednarek-Ochyra & Ochyra 2003). The park warden was delighted to learn that some of the bryophyte cushions with their exceedingly slow growth rates were probably 100s of years old. He has now added bryophyte conservation to the list of reasons why tourists **must** stick to the paths.

Information on the fragility of bryophytes was similarly appreciated when we explained the features of interest along the nature trail in the Laguna del Parilla nature reserve where specimens of all the common species were collected by the Chileans for the herbarium. This final excursion ended on a *Sphagnum magellanicum* bog, one of several we visited. Unlike those in the northern hemisphere the *Sphagnum* bogs of southernmost South America are dominated by this one species with very small amounts of *S. fimbriatum* and the *S. cuspidatum* agg. around the margins. Further north the dominance of *S. magellanicum* prevails but the number of other species steadily increases. Growing amongst the *S. magellanicum* are numerous leafy liverworts with rhizoidal ascomycetes (Engel 1978), mirroring the northern hemisphere (Duckett *et al.*1991) but unique to South America was the endemic moss *Neomeesia paludella*, *Tetraplodon fuegianus*, the only species in this genus in South America and three species of *Tayloria*, *viz. T. mirabilis, T. magellanica* and the rare, round-leaved *T. dubyi.* As is sadly the case elsewhere in the world the Chilean bogs are increasingly threatened by peat harvesting or even worse, since the peat simply oxidizes, thoughtless draining to make way for plantations of very poor quality timber. What struck us most forcibly was that once the original *Sphagnum magellanicum* is removed there was absolutely no evidence of *Sphagnum* regeneration. Most likely this is because other more 'weedy' *Sphagnum* species are absent. Instead the former bogs are overgrown by acres of *Polytrichum strictum* and *Pohlia nutans.*

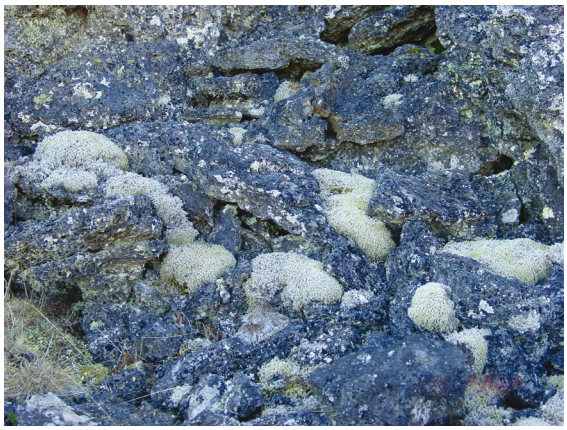

Figure 8. *Racomitrium patagonicum* on lava flow. Photo: Jeff G. Duckett.

Long lasting legacies of this Darwin project will include increasing use of the excellent laboratory facilities in Punta Arenas for both taxonomic and experimental research projects and much greater awareness of the importance of bryophyte conservation in southern Chile. Our visit ended with a flight north to Puerto Montt and a three day visit to the aptly named Darwin Centre on Isla de Chiloé where we provided further guidance to Martin Carmona Ortez on hornwort localities and taxonomy, and made suggestions for a new project on *Sphagnum* growth rates and regeneration (Clymo & Duckett 1986). In the process we discovered *S. capillifolium* in a second locality for Chile and several epiphytes new to the island, for example,

Bryum andicola and *Neckera scabridens*, but this is for another story.

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Tortula freibergii along the Bridgewater Canal

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Tortula freibergii is listed as Low Risk (Near-threatened) in Britain (Church *et al.* 2001) and as Vulnerable in Europe (ECCB 1995). It was discovered in Britain in 1966, from two East Sussex (v.-c. 14) localities: (i) Fairylight Glen in Hastings; and (ii) at Upper Maze Hill, St Leonards-on-Sea (Crundwell & Nyholm 1972). Later, Blockeel & Rumsey (1990) reported the moss from the bank of the Bridgewater Canal in Timperley (Cheshire, v.-c. 58), while Rumsey (1992) discovered a further location at Hayburn Wyke, situated on the coast in North-east Yorkshire (v.-c. 62). I decided to document its distribution along the Bridgewater Canal (Figure 1), particularly as information was required for the forthcoming bryophyte flora of South Lancashire (v.-c. 59).

The River Mersey forms the boundary of v.-c. 59 in the south (Figure 1) so the search started from access points to the canal in the area of Stretford