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The biogeographical position of the Tristan da Cunha archipelago based on floristic records.

Biogeografická pozice souostroví Tristan da Cunha z pohledu floristických studií.

BAKALÁŘSKÁ PRÁCE

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Prohlašuji, že jsem závěrečnou práci zpracovala samostatně a že jsem uvedla všechny použité informační zdroje a literaturu. Tato práce ani její podstatná část nebyla předložena k získání jiného nebo stejného akademického titulu.

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Podpis

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ABSTRAKT

Souostroví Tristan da Cunha je jedním z nejméně porušených temperátních ostrovů světa, s mnoha druhy endemické flory a fauny, nacházející se v Jižním Atlantickém oceánu, přibližně uprostřed mezi Jižní Amerikou a nejjihnějším výběžkem Jižní Afriky. Ačkoliv se jedná o tak zajímavou lokalitu, v mnoha směrech zůstává stále neprobádanou. Bakalářská práce představuje souhrn veškeré dostupné literatury o bezcévných rostlinách vyskytujících se na zmíněném souostroví. Jedná se o značně diversifikované skupiny, přesto vědci mnohdy přehlížené. V rámci bakalářské práce je vytvořen list jednotlivých zástupců. Nakonec je diskutována schopnost bezcévných rostlin se šířit na dlouhé vzdálenosti, jakožto i charakter jejich rozšíření.

KLÍČOVÁ SLOVA: Tristan da Cunha; oceánské ostrovy; botanika; distribuce; ostrovní biogeografie; lišejníky; mechy; játrovky; hlevíky; rozsivky;

ABSTRACT

The archipelago Tristan da Cunha is situated in the South Atlantic Ocean, about midway between South America and southern tip of Africa. It represents one of the least disturbed temperate island systems in the world, supports many endemic plant and animal species. Although the locality is interesting by many aspects, many fields still remain under-studied. This bachelor thesis presents a synthesis of available literature about the archipelagos non-marine non-vascular floras, which are of a great diversity, but mostly still overlooked by scientist. For some of them were made lists of taxa present. Further, the distributional ability and patterns of this plant groups are discussed.

KEYWORDS: Tristan da Cunha; Oceanic islands; Botanic; Distribution; Island Biogeography; Lichens; Mosses; Liverworts and Hornworts; Diatoms;

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1 INTRODUCTION

From the very beginning scientists from all over the world were fascinated by the unique nature of remote oceanic islands, especially since Charles Darwin's work on the Galapagos Islands. These young oceanic islands of volcanic origin are summits of large volcanoes that rose from the bottom of the oceans. They are isolated from other lands by many miles of deep sea and have never been connected to continental landmasses. Their environment is truly unique as everything is fundamentally a product of trans-oceanic dispersal (Wace & Holdgate 1976; Cowie & Holland 2006) and eventually subsequent speciation. Generally, the oceanic islands lack indigenous land mammals and amphibians, but typically have many of birds and insects, and occasionally also some reptiles. They provide us with a suite of natural laboratories, from which the discerning natural scientist can make a selection that simplifies the complexity of the natural world (Whittaker & Fernandez-Palacios 2007).

The Tristan da Cunha group along with Gough Island are not only known because of their remoteness, but also because of the limited human impact, as 44% of the group's land area has been set aside as permanent nature reserve, making it one of the least disturbed temperate island systems in the world (Ryan et al. 2007). Wace (1965) reported that although the Tristan da Cunha archipelago is a remote one, its biota is significantly diverse ecologically with a substantial native flora and fauna in which the pre-human ecological *status quo* is still largely preserved. Two of four island, Gough and Inaccessible Island, were inscribed as UNESCO World Heritage Sites in 1995 (under criteria vii, x) but there is still only a limited awareness of the global importance of this area, the rich species diversity they contain and of the threats they face (Ryan et al. 2007). The island group supports many endemic species, some of which are globally threatened with extinction.

A constant threat for an island's biota is the introduction of non-native species. Alien plant species can be found on all islands of the archipelago, especially on the main island Tristan da Cunha (or 'Tristan'), which is also the most remote inhabited island on the world, with a permanent population of some 270 people who lives in the settlement Edinburgh of the Seven Seas. The three outer islands (Inaccessible, Nightingale and Gough) remain in a largely undisturbed state, despite the presence of a number of introduced species. They are, however, constantly at risk of introduction of new species as a result of visits by tourists, scientists and Tristan islanders (Gremmen & Halbertsma 2009).

ISLAND BIOGEOGRAPHY

Biogeography deals with distribution of species through geological time and in geographical space. Many gradients are involved (e.g., latitude, area, soil, age, isolation etc.) resulting in biogeography as a multidisciplinary domain of many different areas of science – such as evolution, geology, taxonomy, ecology, climatology and palaeontology (Cox & Moore 2010). The tasks of biogeography are briefly, *which species, where and why (or why not?)* as was clearly stated by Quammen (1996). However, Island biogeography has its own arrangements which have to be stated.

The geographic locality of the Tristan da Cunha archipelago is clearly specific by its remoteness and its isolation. Before the actual human influence to the environment, all terrestrial animals and plants have had to **disperse over long distance** from the source. Thus, the biogeography and biodiversity of the archipelago are fundamentally products of trans-oceanic dispersal from elsewhere, subsequently enriched by speciation resulting in endemic biodiversity. This is clear for the islands which have never been connected to a continental landmass (Cowie & Holland 2006). Since plants are not capable of locomotion, seeds and spores can disperse only passively by wind (anemochory) or by flotation in the sea (thalassochory), they also can ‘hitchhike’ on some birds and disperse attached to feathers (exozoochory), legs, or even by the digestive system (endozoochory); birds then use oceanic islands as stepping stones during their migration but will eventually leave behind some species (MacArthur & Wilson 1967; Whittaker & Fernandez-Palacios 2007). Furthermore, the large distance across the ocean defines the species composition found on the islands. Some taxa have inherently worse dispersal abilities thus are unable to colonize more geographically isolated islands. Above that, also some direction of dispersal is often more dominant than the other – like predominant east-west winds ‘West Wind Drift’ around Antarctica in the case of the Tristan da Cunha archipelago (see Fig. 1.1) and other landmasses in the Southern Hemisphere. The wind connectivity among southern islands is clearly a force driving current plant distribution, as for example Muñoz et al. (2004) found a stronger association to floristic similarities of mosses, liverworts and lichens, with maximum wind connectivity than to geographical proximity (using Mantel tests). He also stated that dispersal events are rather episodic than gradual. Nevertheless, the common migratory routes of birds are typically north-south oriented and less in other directions (Gillespie et al. 2012); birds can also provide a distribution of plant species among the southern islands. However, it’s obvious that many species not-adapted to long-distance dispersal would never get there unless with the human help. This results in a highly disharmonic biotic composition on the remote islands lacking many of worldwide common species and also major elements of the biota of continents. Moreover, native species often lack defenses against grazing or predation (Vitousek 1988; Cowie & Holland 2006; Whittaker & Fernandez-Palacios 2007).

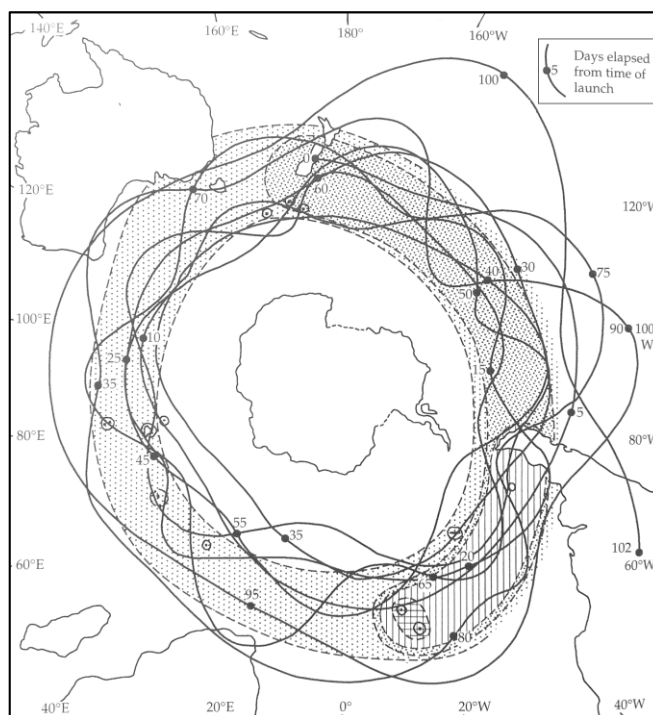


Figure 1.1 Floristic affinities of Gough Island in relation to the predominant wind direction as revealed by the flight of a balloon: areas sharing 20-25 species, cross hatch; 15-20 species, single hatching; 10-15 species, heavy stipple; 5-10 species, light stipple. (Whittaker & Fernandez-Palacios 2007 after Moore 1979) The affinities with New Zealand and South America are clearly visible.

Also the relationship between the number of species and an island area is well documented. More species occur on bigger islands than on the smaller ones, precisely because of the number of habitats (Townsend et al. 2009). This was well presented in the classic monograph by MacArthur & Wilson (1967): *The theory of island biogeography*, in which the **species-area relationship** was clearly specified. The relationship was firstly established for animal species example, but was also extended for botanical species, ending up with similar results. According to them, the number of species on an island is usually approximately related to the area of the island by equation $S = cA^z$, where S is the number of species, A is the size of the area, c is a constant which varies widely among taxa and according to the unit of area measurement (which thus vary from system to system), and z is a constant which is, in most cases, varying between 0.20 and 0.35 (for more details, see MacArthur & Wilson (1967) Chapter 2).

Other idea is that the more isolated an island is, the lower is the species number (Cox & Moore 2010). Unfortunately, with increasing isolation, other properties adherently also vary, such as the area of islands, although the distance effect has been hard to test (Whittaker & Fernandez-Palacios 2007). This phenomenon can be explained by the fact that immigration and evolutionary processes together are not able to achieve a species equilibrium, compared to rates of immigration to islands near major sources (Schoener 2009). This explanation is supported by several recent findings of successful insular colonization by invasive plants. For example Sax et al. (2002) and Sax & Gaines (2008) have shown that although the number of bird species currently found on remote oceanic islands (both native and

introduced) is not higher than the number that was there before human occupation, but the number of plant species almost doubled at the same time, increasing in quantity significantly over last 200 years (Fig. 1.4). These findings suggest that communities may be under-saturated for plants and could support more in total. This also supports the findings of Wace & Dickson (1965) who pointed out that the native biota are disharmonic lacking many species that can successfully invade the native communities not affected by man's activities (as could be seen on several alien therophytes). The dynamics of species distribution on remote islands such as those of the Tristan da Cunha archipelago is therefore much more complicated. Some turnover with endemic plant species becoming extinct and other new species evolved or/and colonizing the island, can be often involved.

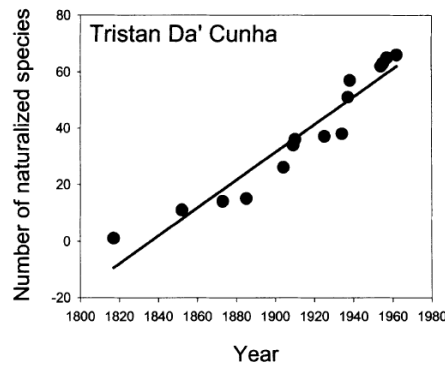


Figure 1.4 Naturalized plant richness has increased on oceanic islands in an approximately linear fashion over the past 200 years. The island does not show asymptote in cumulative richness of naturalized species over time. (Sax & Gaines 2008)

The equilibrium theory of MacArthur & Wilson (1967) (known as ETIB) says that the distribution of species on islands can be interpreted as an equilibrium of opposite powers: extinction and colonization. Species constantly get extinct and substituted through immigration by the same or different ones. The ETIB process depends on the area of the island and its isolation, which, together, drive the speed of immigration and extinction (Fig. 1.5).

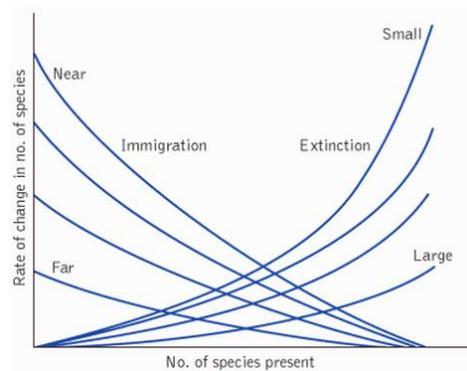


Figure 1.5 The balance between immigration of new species and extinction of already established species on the islands on near, far, small and large islands. Curves intersect at an equilibrium point of biotic diversity. (Cox & Moore (2010) after MacArthur & Wilson (1963))

Beside immigration, other process is often involved, especially on remote isolated islands. Evolution and therefore another possibility how to fulfill the remaining ecological space, comes into question here. Speciation can serve as a surrogate for immigration on isolated islands and will predominantly fulfill the open niches by adaptive radiation when enough time for the process is given. The amount time is less an issue when the islands are remote, because the number of successful colonizers is very low plus the associated abundance of open niches, provide them both time and opportunity to adapt and often evolve to an unusual extent (Gillespie & Baldwin 2010). Both colonization and evolutionary processes are involved in adding new species to the community of an archipelago; it's a race between repeated colonization of pre-adapted species and single lineages that evolve and expand their ecological range (Roughgarden 1972).

Evolution and speciation rates are higher than those of immigration; hence it results in a number of endemic taxa found nowhere else on the world. Then although small in area, oceanic islands maintain a disproportionately high biodiversity and number of endemic taxa than equal-sized areas elsewhere. Consequently, it can be noticed that the isolation of separate biotic regions generally begets global diversity (Cowie & Holland 2006; Vitousek & D'Antonio 1997). It is a paradox that immigration of alien species decreases the diversity of an island flora – actually, it generally increases the total number of species on an island but causes a globalization of species worldwide when driving out the native flora (Lugo 1988; Vitousek 1988). Because of the endemism, it's most welcome to preserve a minimum of colonization events to oceanic islands and still conserve the unique species.

HISTORY HIGHLIGHTS

The very first contact of humans with the Tristan da Cunha archipelago is dated to the 16th century, when there islands were discovered in May 1506 by the Portuguese (Wace & Holdgate 1976) and the northern island was named after Admiral Tristao d'Acunha. Just a year before, in 1505, Gough Island was discovered by Goncalo Alvarez, but later 're-discovered' by Captain Gough of the British ship *Richmond* in 1731 (Ryan et al. 2007).

However, the first recorded landing on Tristan da Cunha was not before 1643, followed by an interest of sealing gangs in killing thousands of seals for oil and skins from about 1790 (Wace et al. 1966; Ryan et al. 2007). In these times, poultry, goats and pigs were introduced and potatoes were cultivated on the island, therefore some alien plants already become established in 1793 (Gremmen & Halbertsma 2009; Wace et al. 1966). However, recent results from the pollen analysis suggest that humans may have visited Tristan da Cunha before the first recorded landing, as pollen of a non-native introduced plant, *Plantago lanceolata* L. was found in one sample of a core from lowland peatland that was dated to around 1570 (Ljung & Björck 2011). The beginnings of the Settlement on Tristan da Cunha date back to the early 19th century, when it was established in 1815 with a self-supporting human population since then. During the 19th century, Tristan da Cunha was an important provisioning station for many vessels

to the Pacific and Indian Oceans, although many visitors came or got by, not only those welcomed – since also rats arrived from a shipwreck in 1882 and caused a massive destruction in native bird populations and to crops. Humans of the Settlement had not only many potatoes plots but as recorded, also other vegetable and fruit growing on the island between 1830 and 1870 – such as cabbages, onion, turnips, carrots, strawberries, apples, pears and peaches. Anyway, by the end of 19th century, the number of seals were so reduced that sealing was no longer profitable and the economy gradually switched from trading to subsistence crofting. Many of islanders left Tristan Island and the population fell by almost half to only 50 people and also, during the first half of 20th century, there was the largest isolation as ships passed by only every one to two years (Wace & Holdgate 1976; Ryan et al. 2007). This changed in the 1940s when a small naval garrison was stationed and also a crayfish caning factory was built, which increased the contact with the outer world. In 1961, a volcanic eruption took place next to the Settlement and everyone had to be evacuated from Tristan. The eruption caused great damage to the vegetation, especially due to fumes that covered a wide area and also due to the grazing of suddenly unwatched domestic animals, although some of them were also reduced by feral dogs (Wace & Holdgate 1976; Gremmen & Halbertsma 2009; Ryan et al. 2007).

According to Wace & Holdgate (1976) the scientific interest began in 18th century. Great account of persons, ships and expeditions who collected vascular plants can be found in Groves (1981). The first big comprehensive scientific survey of the northern islands was done by the Norwegian Scientific Expedition in 1937–38. Later on, on Gough Island, a first expedition was made by the Gough Island Scientific Survey in 1956–57, which built up an expedition hut at The Glen on the east coast, later moved and maintained as a South African Weather Station in 1963. The first proper exploration of Inaccessible Island was done by the Denstone Exploration in 1982–83.

The lowland areas of Tristan da Cunha were exposed to substantial disturbances since the 17th century as indicated by the erosion of the Settlement Plain (Ljung et al. 2006). Most of the original lowland areas of Tristan have been transformed by intensive agricultural and grazing activity into grassland dominated by alien plant species (Gremmen & Halbertsma 2009). Eventually, the first effort of protecting the unique and greatly threatened environment of the Tristan da Cunha archipelago, took place in 1976 when the Conservation Ordinance proclaimed Gough Island as a nature reserve and provided some protection for seabirds and Island Trees at Tristan. As was mentioned before, also Inaccessible Island was turned into a nature reserve and together with Gough Is., both islands form one of only two British Natural World Heritage Sites in the UK Overseas Territories. Also half of the total surface of Tristan da Cunha Island is protected. Furthermore, the community has adopted a Biodiversity Action Plan (in 2006), controlling imported goods because of the threat of future accidental introductions and also took its part in eradication programs for invasive alien species, as are New Zealand Flax, Procumbent Pearlwort or rats and mice (Ryan et al. 2007).

OBJECTIVES AND IMPORTANCE OF THE STUDY

As we can see from recent paleoecology studies (Ljung 2007) the Tristan da Cunha archipelago had been unaffected since its emergence to at least the late 16th century, and remained fairly untouched until the first documented human landings in the 17th century. According to Ljung et al. (2006) the vegetation has been rather stable for at least 2300 years, with no significant altitudinal shifts in the vegetation zones or major changes in the species composition. Also pollen studies from Gough Island do not record any major vegetation changes indicating that the island flora seems to be remained similar for at least 40,000 years (Bennett et al. 1989). This may indicate that the island biota had reached its own point of succession, well before any human appearance. Truly, the environment of the islands belonged to no-one but nature and can thus be considered a true product of natural laboratories.

The main aim of this bachelor thesis is to summarize all records known about non-marine non-vascular flora that occur on the archipelago Tristan da Cunha. At present, such a summary does not seem to exist on this topic. It can help future researchers working on ecology, climatology, biogeography and distribution of micro-organisms in the Southern hemisphere. Together with background works done predominantly on vascular plants (Wace & Holdgate 1958, 1976; Wace 1961; Wace & Dickson 1965; Groves 1981; Ryan et al. 2007), this thesis can help to understand some biogeographical questions.

Due to its position, the archipelago has a great scientific potential as one of the most remote places on the world. This can be advantaged for comparisons with other similar isolated islands such as Ile Amsterdam and St. Paul in Indian Ocean. These two islands, although in a different ocean and apparently some 7,400 km away, have similar climatic conditions as southern Gough Island and also are already known for some floral and faunal similarities (Wace 1961). For example, the Gough-Amsterdam connection involves Northern rockhoppers, Yellow-nosed albatrosses, some *Sphagnum* species (absent from sub-Antarctica) and also the endemic Island tree, *Phyllica arborea* (Van de Vijver, personal communication). Following this thesis, future research targeting especially micro-organisms from Gough Island may bring new information for this connection, as recent studies on Ile Amsterdam are already being undertaken (Van de Vijver et al. 2008, 2012; Lowe et al. 2013; Van de Vijver & Cox 2013; Chattová et al. 2011, 2014). Other biogeographical relationships can be studied based on floristic records – with geographically neighbouring islands and landmasses (such as Saint Helena, southern Africa, Bouvet Island, South Georgia, Marion and Prince Edward Islands) or based on dispersal wind highway from the East (New Zealand, Tierra del Fuego, South America etc.) to the West (Ile Amsterdam, St. Paul Island etc.).

2 TRISTAN DA CUNHA ARCHIPELAGO

The Tristan da Cunha archipelago, governed by the United Kingdom, is a dependency of the British overseas territory of *Saint Helena, Ascension and Tristan da Cunha*. The archipelago, located in the South Atlantic Ocean, is composed of four major islands and a large number of smaller islets. The first three, **Tristan da Cunha**, **Inaccessible** and **Nightingale** (37 °S/12 °W) are only separated by narrow sea straits of less than 20-40 km and are commonly referred to as the ‘Tristan Group’, named after the main island of the archipelago, Tristan da Cunha. The fourth island, **Gough Island**, located more than 350 km south-southeast of the Tristan Group (40 °S/10 °W), is the only other landmass within 2,000 km of the Tristan Group (Wace & Holdgate 1958). Other closely located landmasses include for instance Saint Helena Island at 2,430 km away to the North. For better understanding of its locality, see Figure 2.1.

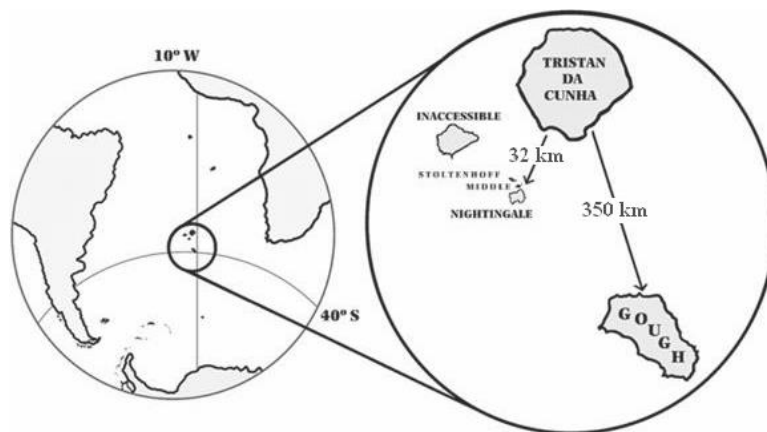


Figure 2.1 Locality map of the Tristan da Cunha archipelago in the South Atlantic. After Hänel (2008).

GEOLOGY: ORIGIN AND STRUCTURE

The archipelago is one of the most remote places in the world, 2,800 km away from Cape Town, over than 3,250 km from South America and approximately 3,430 km from the Antarctic Continent. The islands are entirely oceanic, formed after a series of volcanic events, which means that they represent the exposed parts of large volcanos and have never been connected to any continent or larger landmass. The islands are positioned slightly east of the mid-Atlantic Ridge near its junction with the aseismic Walvis lateral ridge, and rise from a water depth of about 3,500 m (Wace & Holdgate 1976). Nevertheless, the sea straits between Nightingale and Inaccessible Isl. never exceed more than 500 m of depth and they are separated from Tristan da Cunha, situated on different volcanic plinth, is it less, some 2,000 m (Ryan et al. 2007).

The islands, although all of volcanic origin, differ in age. It's remarkable and not so obvious for an archipelago lying so closely together, compared to for instance the Galapagos Islands or the Hawai'i archipelago. Although they had some periods of volcanism and still are not volcanically entirely extinct, the age of every island is noticeable by the erosional stage, size and structure. The oldest one is

Nightingale, with rocks on one of its islet, Middle Island, being more than 18 million years old. The island, the smallest of the archipelago (4 km²) is highly eroded, with two neighboring islets, **Stoltenhoff** and **Middle** (or Alex) **Island**, and many low cliffs and sea caves. The island culminates at High Ridge, with an altitude of ca. 400 m. **Inaccessible Island** is much younger (3 - 4 million years old), is medium-sized (14 km²) culminating at 600 m (Swale's Fell). It's mostly eroded from the western side, where are the highest cliffs of the island, from them the remaining surface then slowly sloping down to the east. **Tristan da Cunha**, the only inhabited island of the archipelago with a population of less than 300 people, is also the largest (96 km²) and the youngest one. The oldest rocks are only about 200,000 years old. Furthermore, it is the last one that showed volcanic activity when it erupted in 1961 forming a new volcanic cone just north-east of the Settlement (Edinburgh), covering an area of about 0,5 km² in new lava (Gremmen & Halbertsma 2009). The island itself has a typical volcanic shape, reaches 2067 m at its highest point (The Peak) around which a gently sloping terrain called The Base can be found. It is surrounded by steep precipices known as The Cliffs (Ljung et al. 2006) formed by marine erosion. Tristan has also coastal lowlands – the settlement plain on north-west, where Edinburgh is located, and then Caves-Stony Beach on the south side and the small Sandy Point on the eastern side. The last and most isolated island is **Gough Island** with an age of about 3 - 5 million years (Ryan et al. 2007). It is actually the tip of a large volcanic mass, completely separated from the Tristan group, with an erosional state between Inaccessible Isl. and Tristan da Cunha (Miller 1964). The highest point, Edinburgh Peak, has an altitude of ca. 910 m, surrounded by a plateau at 600 m a.s.l. with eight large and deep canyons known as the 'glens' formed by fluvial erosion. Steep cliffs are found mainly on the western coast whereas the plateau on the south slopes down more gently, although the area is very crossed by many small gullies, including only an extensive area of land below the 300 m contour (Wace 1961). This is where the Meteorological Station of South Africa is located inhabiting permanent 7 occupants. Gough itself has also many small islets and rocks, such as Saddle Is. on the south, Tristani and Isolda Rock on the west, Cone Is., Round Is., Church Rock and Loft's Wife on the north and Pinguin Island more to the east with The Admirals on the east side.

CLIMATE

The Tristan da Cunha archipelago has a strong oceanic influence, expressed by the typically wet and often windy weather with a relatively stable annual temperature due to lagging effect of the surrounding ocean. The islands are classified as a 'cool temperate' (Wace & Holdgate 1958; Wace & Holdgate 1976; Preece et al. 1986; Ryan 2007) together with Ile Amsterdam and Ile Saint-Paul, both located in the southern Indian Ocean (Clark & Dingwall 1985).

The Tristan Group is only about 250 km below the southern tip of Africa and can therefore have relatively warm summers. The marine west coast climate is very typical lacking a dry season with an annual temperature of 15,1 °C (range 2 to 25 °C) at sea level, decreasing with rising altitude. The mean

annual precipitation of Tristan da Cunha is 1,670 mm (Holmgren et al. 2011).

The Subtropical Convergence is situated sometimes between the Tristan Group and Gough Island, sometimes more southward. It's the boundary between the warm Subtropical surface waters coming from the north and the cold sub-Antarctic surface waters from the South. Moreover, Gough is being influenced by the upwelling of cool subsurface waters and its position is right on the edge of the so-called 'roaring forties', making the weather on Gough rough, especially during the winter months. The annual average precipitation of Gough is approximately 3,000 mm and it rains almost 300 days per year with frequent gale-force winds (Elix et al. 2005). Gough Island's average annual air temperature is 11,7 °C, varying between 8,9 °C in August and 14,5 °C in February (Jones et al. 2003) at sea level and the annual precipitation averages the total for Transvaal Bay (site of the Weather Station) of 3,154 mm (Turner & Pendlebury 2000).

According to Ryan (2007), the precipitation is up to 50 % higher on the peaks than at the coast. This is mainly because the islands are mountainous (especially Tristan da Cunha and Gough) and orographic clouds formed around the peaks induce an orographic rainfall from the cool moist air (Wace & Holdgate 1976). The West Wind Drift affects the archipelago, with predominantly winds from the west (36 km/h at Tristan and 44 km/h at Gough, with a tendency to be stronger during winter months (Ryan et al. 2007)). The precipitation levels are the highest during the winter months when the west winds move northward and bring more cyclones to the islands along with higher sea surface temperature increasing the level of air humidity (Ljung & Björck 2007).

In the past, the island has not been glaciated (Chown et al. 1998). Pollen analyses from cores suggest that the climate remained relatively constant during at least the last 20,000 years. According to Bennett et al. (1989), the vegetation on Gough (and hence the climate) did not experience any major changes in at least the past 40,000 years. However, the actual climate is influenced by Global Change, as an increase in temperature has been noted since the 1950s and especially pronounced since late 1970s (le Roux et al. 2013). It is generally known that warmer temperatures may improve the ability of alien invasive species to settle, reproduce and successfully outcompete native biota which can lead to significant biodiversity loss.

HABITAT TYPES

Terrestrial habitats found on the Tristan group and Gough Island, are defined by their dominating plant communities. Natural vegetation zones tend to be subdivided by altitude, depending on their exposition, generally at lower elevation at Gough Island than at the northern islands. A brief overview of the habitats present on the archipelago can be found in this section, their composition and structure, starting from sea level:

TUSOCK GRASSLAND AND PASTURES: These grasslands are dominated by high (up to 3 m) and dense tussock grass *Spartina arundinacea* (Thouars) Carmich, covering almost the entire surface of Nightingale and its islets – Middle and Stoltenhoff, coastal lowlands and cliffs of Inaccessible up to 200-500 m. Once this vegetation was dense at Tristan but is now replaced by pastures (Wace & Holdgate 1976; Ryan et al. 2010). Pastures can be found on Tristan at the base of the fringing coastal cliffs on the Settlement Plain, The Caves, Stony Hill and Sandy Point. *Spartina* tussock cover is less developed at Gough, concentrated to offshore stacks, cliffs and slopes. The smaller tussock grass *Parodiocloa flabellate* (Lam.) E.E. Hubb, is forming a dense cover, especially along the western cliffs, but is excluded from areas that are naturally disturbed therefore providing an opportunity to some plants such as Pig Dock (*Rumex frutenscens* Thouars), and also to numerous introduced species to proliferate (Ryan et al. 2007; Wace 1961).

FERN BUSH: Dense fernbush communities of *Phylica arborea* Thouars, the Island Tree (5 to 8 m high, sheltered places), joined by Bog Fern (to max. 2 m) *Blechnum palmiforme* (Thouars) C.Chr., are the two main distinctive species that characterize the Fern Bush vegetation zone. This vegetation zone can be found on all four islands, up to around 800 m at Tristan, on the wet peaty plateau of Inaccessible and on the area around the Ponds at Nightingale, as well as on Gough up to 500 m, where it selects more sheltered sites along the east-south coasts (Ryan et al. 2007; Wace & Holdgate 1976). Usually in upper highs and on more exposed places, Bog Ferns heath communities grow, while *Phylica* woodland seems to prefer more sheltered places and is excluded from areas above an altitude of 450 m. The trunks of *Blechnum* and also *Phylica* wood lying on the ground are covered with a thick growth of *Hymenophyllum aeruginosum* (Poir.) Carmich, whereas many bryophytes grow under the thick *Phylica* canopy and many species of epiphytes can be seen on the branches, such as for example dense growths of Old Man's Beard lichen *Usnea* Dill. ex Adans., where a certain amount of orographic mist is frequently occurring. Other plants are often found in a dense ground cover among trees, where they are more scattered – Bog Ferns, *Ctenitis aquiline* (Thouars) Pic.Serm, Bracken *Histiopteris incise* (Thunb.) J.Sm., *Elaphoglossum laurifolium* (Thouars) T. Moore and *Asplenium obtusatum* G.Forst., many flowering plants including Dog Catcher *Acaena sarmentosa* Carmich., Berry Bush *Empetrum rubrum* Vahl ex Willd. and fowl berries *Nertera* spp. Banks & Sol. ex Gaertn., in such places as is area between the Ponds on Nightingale, the Small Bog Grass *Scirpus bicolor* Carmich. can be found (Wace 1961; Ryan et al. 2007).

WET HEATH: The Wet Heath vegetation zone includes many elements of other zones, making itself a transitional vegetation type of plants only less than 0.5 m short, found approximately between 300 and 600 m, from the upper limit of Fern Bush. It consists of scattered dwarfed ferns *B. palmiforme*, *B. pennamarina* (Poir.) Kuhn and *Ctenitis aquilina*, a large number of mosses, grasses, *Scirpus* and *Carex* sedges and other flowering plants including Dog Catcher, fowl berries, Celery *Apium australe* Thouars, *Empetrum rubrum* etc. This zone does not occur on lower Nightingale Island but is common on Gough

Island to above 800 m when sheltered. Also occur on small area on the highest western rim of the plateau at Inaccessible Island, but is former to Tristan, now shifted to meadows dominated by two alien species *Holcus lanatus* L. and *Rumex acetosella* L. (Wace 1961; Ryan et al. 2007; Wace & Holdgate 1976).

FELDMARK AND ALPINE HABITATS: At the higher elevations of Tristan and lower on Gough, where the Wet Heath vegetation zone ends and soil is more exposed and windswept, only some plants can survive. The diversity depends on soil stability and depth, which is diminishing with altitude. *Empetrum* communities, *Agrostis* grasses and *Scirpus* sedges, *Celery Apium australe*, Tristan Cranberries *Acaena stangii* Christoph. and the lycophytes (e.g., *Lycopodium magellanicum* Willd.), together with numerous mosses and lichens, form the common vegetation of feldmarks; only few hardy lichens and mosses can reach the montane scoria Tristan Peak (Wace 1961; Wace & Dickson 1965; Ryan et al. 2007).

BOGS AND OTHER WETLAND HABITATS: Bogs and wetlands are widespread at the islands, forming two main types of bogs. At lower elevation they are dominated by floating mats of dense Big Bog Grass *Scirpus sulcatus* Thouars. Typical examples of these are the Ponds at Nightingale and Skua Pond at Inaccessible, with *Scirpus* bogs as well as with open patches of water, mud, and with Pig Dock and *Carex insularis* Carmich. sedges on the edges. The other type consists of *Sphagnum* bogs, which typically occur at higher elevations, locally on the plateau of Inaccessible and on the Base of Tristan (Soggy Plain, at 740 m). More extensive bogs are found in the Gough Island uplands where wetter conditions and suitable flatter topography prevail above 600 m. These peatbogs are dominated by *Sphagnum* mosses (*S. recurvum* Beauv.), other bryophytes and a number of liverworts (e.g., *Jamesoniella* spp. (Spruce) Lees), along with the only abundant plant *Tetronicum magellanicum* Willd. on Gough and also *Scirpus* sedges, common in these bogs at the northern islands (Glass et al. 2006; Ryan et al. 2007; Wace & Holdgate 1958; Wace & Dickson 1965; Wace 1961). Drainage bog streams are also present, and are surrounded by mixed fen-like vegetations including *Glyceria insularis* C.E. Hubb. and *C. insularis* differing from the Wet Heath community. Likewise *Agrostis* and *Deschampsia* grasses are abundant, as well as introduced plants dispersed along streams, such as the widespread *Rumex obtusifolius* L. and the aggressive alien *Agrostis stolonifera* L., both looking for disturbed openings after floods (Ryan et al. 2007; Wace 1961).

THE 1961 LAVA FIELD AND VOLCANO: The area is characterized by a young volcanic substratum, lacking any soil formation and showing a very low water retention capacity. Only large black lava blocks or fine-grained sandy deposit on the new volcano form the substratum (Gremmen & Halbertsma 2009).

3 FLORISTIC RECORDS

Although vascular plants dominate the terrestrial vegetation of the islands, it's noteworthy to say that this is reflected in the species richness which is much larger in non-vascular plants. Even Wace & Dickson (1965) mentioned, although the species number recorded was significantly lower than nowadays, the abnormally high proportion of mosses and hepatics compared to phanerogams on the archipelago, based on Raunkiaer's 'quotients' for bryophytes (Fig. 3.1).

	<u>no. of mosses x 11</u> no. of phanerogams	<u>no. of hepatics x 25</u> no. of phanerogams
Tristan da Cunha archipelago	40	137
Juan Fernandez group	11	35
South Georgia	73	84
Faeroe Islands	10	12
Azores	2	3

Figure 3.1 An exceptionally high proportion of bryophytes to phanerogams, even for insular flora.

After Wace & Dickson (1965); data from Wace & Dickson (1965), Raunkiaer (1937) and Skottsberg (1956).

Although there is a higher number of species, the level of endemism is lower compared to vascular plants. It's due to the effective long-distance dispersal ability of spores which is even more effective for vegetative propagules, via birds, ocean current and West Wind Drift (Galloway 1996; Jørgensen 1977; Elix & Gremmen 2002). According to this, the distribution of species clearly shows some phytogeographical affinities to some continental landmasses, as would be discussed below or in the Discussion (from p. 22).

LICHENS

Lichens are widespread among the islands of the Tristan da Cunha archipelago. They grow on different substrates, from the sea level up to the highest point of the Tristan Peak. Foliose, fruticose and some crustose lichens specimens were collected from the islands and described by different authors. The first comprehensive collection made, was provided during the Norwegian expedition to Tristan da Cunha in 1937-38 when mostly foliose and fruticose lichens were collected. From the collection of crustose lichens, des Abbayes (1940) treated the genus *Cladonia*, and Lamb (1940) the genus *Placopsis*. The first summary of lichens listed in publications (together with some unpublished identifications of Gough's species done by Mr. Peter James) was done by Wace & Dickson (1965, p. 353) who recorded 49 species. Foliose and fruticose lichens from the first collection of Norwegian expedition, were later mastered by Jørgensen (1977) who recorded 84 species from the Tristan group. He also stated that some of the listed species by Wace & Dickson (1965) are either synonyms, incorrectly identified or of dubious status. He also corrected his own findings later (Jørgensen 1979). It is worth mentioning that scientific knowledge of the archipelago lichen flora is still developing as new species are being found and described, and so as with some genera already known. A new collection was made during past two decades by Niek

Gremmen¹. Specimens from both collections mentioned previously were studied, and a descriptions of several new lichen species were published (Elix & Gremmen 2002; Elix et al. 2005; Øvstedal & Gremmen 2010; Elix et al. 2011). I combined all the publications listed and revised the lichen species for synonymy; note that no classified lichenologist has checked this list (see Appendix 7.1). The total number of the species in Appendix 7.1 therefore may be an overestimate of the real amount species recorded from the islands, as I preserved doubtful records.

The discussion of the lichen flora found in this paragraph was done after the sources listed (Jørgensen 1977, 1979; Ryan et al. 2007; Elix et al. 2005, 2011; Elix & Gremmen 2002; Øvstedal & Gremmen 2010). Lichens are widespread on the islands, common on rocks along the coast as well as at high elevations. Some of them live right on the ground (e.g., *Stereocaulon* spp. Hoffm., *Parmotrema perlatum* (Huds.) Ach.), others can maintain it also on the roots of *Spartina arundinacea* (such as *Dirinaria applanata* (Fée) Awasthi, which is the most variable there in habitat choice) growing from the sea level. Others prefer to inhabit places, close to bird colonies, though are often fertilized, such as for example *Punctelia canaliculata* (Lyngé) Krog (which is normally corticolous, on Gough Is. that is growing on coastal rocks), *Ramalina* cf. *laevigata* Fr., *R. scopulorum* Ach., *Parmotrema reticulatum* (Taylor) M. Choisy and *Heterodermia speciosa* (Wulf.) Trevis. Near the beaches *Tephromela rimosula* Øvstedal is often found. Many lichens of the subgenus *Parmelia* are often found within the Settlement (*Parmelia microspore* Müll. Arg., *P. revolutella* Nyll., which is an endemic species to Tristan da Cunha and St. Helena, *P. maura* Pers., *P. cetrata* Ach. coll. and *Parmotrema crinitum* (Ach.) M. Choisy), while others live just nearby ferns (e.g., *Ramalina* cf. *linearis* (Sw.) Ach., *Peltigera dolichorhiza* Nyl.). The most common parmelioid species on Gough Island, *Parmotrema reticulatum*, prefers to live close to human occupation, which couldn't be overlooked as grows on the wooden stairs at entrance to base building and also forms large clumps as common epiphyte in dense *Phylica* thickets. Among other common species (on all islands and often not selective on materials) can be mentioned: *Parmelia maura*, *Parmotrema crinitum*, *P. perlatum* and *Dirinaria applanata*, but also *Leptogium denticulatum* auct. non. Nyl. (growing on low elevation on *Phylica*, *Salix* and apple trees) and *Pseudocyphellaria intricata* (Del.) Vain.. However, on higher altitudes, common species are those of *Ramalina* Ach. or 'Snow Lichens' of *Stereocaulon*, and other worth to mention since living inside the crater at 1950 m a.s.l. – *Peltigera friesiorum* Gyeln., *Stereocaulon glabrum* (Müll. Arg.) Wain. and *S. vesuvianum* Pers., which is the most widely distributed one reaching Spitsbergen in the Arctic Region, although many other extend as far as Norway. Some species are restricted to these high levels and it won't be surprising to find them nowhere else but on the Peak of Tristan. Actually, as Wace & Holdgate (1958) stated, due the extreme exposure, wind condition and the instability of volcanic cinders only some small fruticose and crustose lichens can survive. Other lichen species use bryophytes in heights (e.g., *Psoroma hypnorum* (Vahl) S.F.

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Gray var. *paleaceum* (Fr.) Rostr. and *Stereocaulon implexum* Th. Fr.) to maintain it at more exposed places, but grow on the ground/trees at lower elevations. However, there are some species such as *Massalongia griseolobulata* Øvstedal, *Parmotrema arnoldii* (Du Rietz) Hale and *Pseudocyphellaria intricata*, seeking for bryophytes anywhere, or some growing on peat surface in shady and humid places, as *Lepraria goughensis* Elix & Øvstedal. Brook stones are often inhabited by *Parmelia revolutella*, *P. rockii* Zahlbr., the endemic *R. elegantula* P.M. Jørg (also on the peak of Nightingale) and *Usnea vermicularis* P.M. Jørg., rock faces by *Parmelia* spp., *Ramalina* spp., *Usnea ceratina* Ach. and endemic *U. nigropapillosa* P.M. Jørg.. Not only bryophytes, but also Island Berries *Empetrum rubrum* are often occupied by lichens (e.g., *Parmeliella pycnophora* (Nyl.) R. Sant., *Polychidium dendriscum* (Nyl.) A. Henssen, *Pseudocyphellaria intricata* or *Sticta ambavillaria* (Bory) Ach.) as well as Bogfern's stems of *Blechnum palmiforme* (e.g., *Hypotrachyna microblasta* (Vain.) Hale, *Parmotrema gardneri* (C. W. Dodge) Sérus. and *Massalongia griseolobulata* – endemic to Gough Is.) and Bogfern community (*Leptogium lacerooides* B. de Lesd., *Hypotrachyna microblasta*). However, the most overgrown by lichens are the Island Trees *Phyllica arborea*. Species of *Parmelia*, *Sticta* (e.g., *Parmeliopsis afrorevoluta* (K. & S.) Elix & Hale, *Sticta tessellata* Øvstedal, *S. fuliginosa* Nyl. (Dicks.) Ach.) and *Pseudocyphellaria* are common epiphytes; branches of many Island Trees are often densely covered by lichens. Some seek open *Phyllica* bush vegetation (e.g., *Hypotrachyna bogotensis* (Vain.) Hale, *Sticta tessellata*, *Parmelia revolutella*) while others not so much (e.g., *Parmotrema gardnei*, *Szczawinskia phyllicae* Øvstedal together with *Polychidium* spp. (Ach.) Gray, *Hypotrachyna endochlora* (Leight.) Hale, *Parmeliella nigrocincta* (Mont.) Müll. Arg. and *Usnea dasycera* (Nyl.) Mot.). Many species are reported from the Nightingale Lake region, for example *Heterodermia casarettiana* (Mass.) Trevis., *H. leucomela* (L.) Poelt and *H. endochlora*, *Parmelia dilatata*, *Parmotrema perlatum*, *Ramalina celastri*, *R. peruviana* Ach. coll., *R. tayloriana* Zahlbr., *Teloschistes flavicans* (Ew.) Norm., and *Usnea ceratina* which can also be found on exposed cliffs of Nightingale. *Parmotrema arnoldii*, *P. crinitum* and also the recently found endemic to Gough Island, *Cresponea soredata*, often grow over dead *Phyllica* wood and other plant remains.

BRYOPHYTES

MOSESSES (MUSCI)

Mosses are, together with lichens, the most conspicuous terrestrial non-vascular plants on the Tristan da Cunha archipelago. They are often found in high abundance on places where other plants do not occur, especially due to extreme weather or habitat conditions, often in places similar to lichens. The Scottish National Antarctic Expedition (April in 1904), Shackleton–Rowett Expedition (June, 1922) and The Norwegian Antarctic Expeditions (1927–1928), made the first collections on the islands (reported 26 moss species in total), but the first comprehensive study was not made until the Norwegian expedition to Tristan da Cunha in 1937–38, when probably more than 1000 specimens were collected by

E. Christophersen and Y. Mejland (Dixon 1960). The largest contribution to our knowledge of the moss flora on the archipelago was certainly made by Edwin B. Bartram (in Dixon 1960; Bartram 1959) and H.N. Dixon (Christophersen 1934; Dixon 1960). The only other contribution was that of Wace & Dickson (1965) who published a table of moss species based on Dixon (1960) and also on the personal collection of N.M. Wace on Gough Island and Tristan in 1955-56. Unfortunately, from the 1960s, only two, smaller, publications appeared (Ochyra 1999; Dickson 1967) containing remarks on mosses of the archipelago. It is possible that others exist, but up to now, we were unable to trace any. For the list of moss species present, see Appendix 7.2. I kept the doubtful records, but marked them with a question-mark. As is reported in Ryan (2007), the total number of moss species should be at least 150 which agree with number of species in Appendix 7.2, but the total number of species present may be much higher as the islands are still under-collected.

The discussion of the observed moss flora in this paragraph is based on the sources listed: Ryan et al. 2007; Wace & Dickson 1965; Bartram 1959; Dixon 1960; Christophersen 1934; Wace 1961; Glass et al. 2006. Mosses are widespread on the archipelago; as epiphytes, in gulches, on moist rocks, covering ground beneath the vascular plants, or as dominant plants higher in the mountain. However opposite of lichens, mosses are rather not in areas heavily influenced by sea spray. If they occur by the sea, they often choose cave walls (*Fissidens leptochaete* Dus., *Amblystegium patenti-flexuosum* Dixon, *Bazzania skottsbergii* (St.) Fulford., *Rigodium crassicostatum* (Dix.) Bartr., and *Cyclodictyon laete-virens* (Hook. & Tayl.) Mitt. the 'Bright Green Cave-Moss'), sea cliffs (*Bryum tenellicaule* Card.) or wet rocks opposite to salt spray (*Pohlia wahlenbergii* (Web. & Mohr) Andr., *Drepanocladus fluitans* (Hedw.) Warnst.). Some can also be found on the wet sand ground (*Dicranella hookeri* (C. M.) Card.), further from the sea (*Trichostomum aequatoriale* Spr.) or on the edge of the beach (*Brachythecium subpilosum* (H.f. & W.) Jaeger). Also waterfalls ending near the sea and running water on beaches are often occupied by mosses, attached to wet stones (*Breutelia popinqua* Kaal., *Brachythecium subpilosum*, *Racomitrium lamprocarpum* (Müll. Hal.) Jaeg.) or growing in the running water (*Pohlia excurrens* (Dixon) E.B. Bartr., *Philonotis tenuis* (Tayl.) Jaeg., *P. vagans* (H. & W.) Mitt. and *Bryum fluitans* Dixon, the true aquatic species). Species that prefer aquatic habitats occur at lower altitudes (up to 600 m). These can be found in (or just by) brooks and streams (the endemic *Funaria euryloma* Dixon, *Bartramia patens* Brid., the probably entirely aquatic *Fissidens fluitans* Dixon or recorded as floating masses, *Hypnum cupressiforme* Hedw., *Rhynchostegium irriguum* Dixon and *Trematodon intermixtus* Card.), on the edges of ponds (*Blindia subcapillifolia* Dixon, *Dicranella vaginata* (Hook.) Card., *Dicranoloma perdecurrens* Dixon, this one also occurs up to 2000 m) or on dripping stones, basically at any altitude where they occur (e.g., endemic *Bryum subantarcticum* Dixon, *Didymodon austroalpigena* (C.M.) Broth., *Pleuropus bonplandi* (Hook.) Broth., *Philonotis vagans*, *Psilopilum laxifolium* Dixon, *Racomitrium nigratum* (C.M.) Jaeg.). However, the habitats in upland areas of the two larger islands are subject to drier conditions. Plant species there are often exposed to desiccation stress when growing on rocks, on relatively dry soil, or in

open vegetation. Species of *Racomitrium* are well-adapted to the rough weather conditions and are important pioneers to colonize, and also stabilize, some of the cinder slopes (*R. lanuginosum* (Hedw.) Brid., also known as 'wooly moss', *R. laevigatum* A. Jae., *R. crispulum* (H.f. & W.) H.f. & W., and the endemic *R. gracillimum* Dixon; at least the last two were also found at the highest point of the peak). Likewise abundant are the granite mosses *Andreaea* spp., forming dense reddish or black cushions on rocks at high altitudes (the endemic *A. atlantica* Dixon, *A. grimmioides* Dus. and two other often abundant in crater of the Peak: *Andreaea parallela* C.M. and *A. regularis* C.M.) and others (e.g., *Chrysoblastella chilensis* (Mont.) Reimers, *Ditrichum hyalinum* (Mitt.) Par., endemic *Ditrichum tenuinerve* Dixon, *Hennediella kunzeana* (Müll. Hal.) Zand., with some of *Thuidium* spp., *Tortula* spp., and *Polytrichum* spp.). In the upper parts of Tristan (from 1200 m), mosses are important habitats for some lichen species (e.g., *Psoroma hypnorum* var. *paleaceum*, see above) and are also often found in association with flowering plants (*Racomitrium crispulum*, *R. lanuginosum* and various Dicranaceae). *Empetrum* heath, present from low levels to some 1200 m a.s.l., is also hospitable for mosses, abundant beneath the berry species (for example, endemics *Bryum cymbifoliellum* Dixon, *Campylopus alienus* Dixon and *Psilopilum tristaniense* Dixon). Also mosses occur on trunks, branches and twigs of *Phyllica* trees, but not in such high abundance as lichens, this includes for example *Campylopus pyriformis* (Schultz) Brid. (also in *Scirpus* tussocks), *Hypnum chrysogaster* Müll. Hal., and endemics *Macromitrium antarcticum* C.H. Wright, *Zygodon insularum* Dixon and *Rhynchostegium isopterygioides* Card. The shades of the tree-fern community are also used by others, namely *Dicranoloma* spp., the endemics *Dicranodontium tristaniense* Dixon & Thér. and *Daltonia tristaniensis* Dixon, *Dicranella hookeri*, *Chorisodontium aciphyllum* (H.f. & W.) Broth., *Bartramia ithyphylla* Brid. and the endemic *Breutelia tenuifolia* (Mitt.) Par. In association with *Scirpus* tussocks, often on roots, others can be found (e.g., *Ceratodon purpureus* (Hedw.) Brid.,). Other habitats, where mosses are dominant, are valley and plateau bogs and especially those on the southern Gough Island. *Sphagnum* species are the principal peat-forming plant there, and form large tufts in pioneer vegetation on recent peat-slips (e.g., very abundant *S. recurvum* Beauv). *Ptychomnion densifolium* (Brid.) Jaeg., *Racomitrium lanuginosum*, *Sphagnum magellanicum* Brid., *S. fimbriatum* Wils., *Campylopus richardii* Brid., *Braunia humboldtii*, and the endemic *Dicranodontium tristaniense*, are the ones that typically form valley bogs. The plateau bogs (at approximately 600 – 700 m) forms a more humified peat than the valley bogs. *Dicranoloma* spp., *Braunia humboldtii* are important species there, together with numerous small hepatics. *Sphagnum* spp., although still in large amount, are less important there. Eventually, some species that can be found in the Settlement, within the pastures, grasslands or potato patches, are for example the endemic *Amblystegium stricto-serpens* Dixon, *Bartramia ithyphylla* Brid., *Bryum amplifolium* Dixon, *B. truncorum* Brid., *Ceratodon purpureus*, *Funaria euryloma*, *Leptodontium interruptum* (Mitt.) Broth. and *Orthotheciella varia* (Hedw.) Ochyra.

LIVERVORTS (HEPATICAE) AND HORNWORTS (ANTHOCEROTAE)

Liverworts and hornworts are the best discussed group of bryophytes, and maybe also of non-vascular plants in general. The first comprehensive collection was also done by the Norwegian expedition between Dec 1937 and Mar 1938. Specimens from the expedition were mostly identified by S.W. Arnell (Arnell 1958), who also determined the collection of N. Wace after the Gough Island Scientific Survey (Oct 1955–Mar 1956). Other expeditions that contributed to the collection of liverworts and hornworts were done by N.J.M. Gremmen (Sep 1999, Jun–Sep 2000, Sep 2005, and Nov 2007–Feb 2008) and these were determined by John J. Engel² and Jiří Váňa³, both also did the identification of many smaller collections throughout last 60 years. After their venerable work on hepatics from the Tristan da Cunha archipelago (Engel 1977; Váňa 1998), they managed to published ‘memoirs’ *The Liverworts and Hornworts of the Tristan da Cunha Group of Islands in the South Atlantic Ocean* (Váňa & Engel 2013), where all species known are gathered along with literature records and ecology, together with findings of distribution and a history of exploration. Complete knowledge of this plant group can be found in the publication, as well as lists of all taxa reported from the archipelago throughout the time (p. 123–125 and 131–135).

Liverworts have the majority of taxa known in this group from the archipelago. Only four species of hornworts are reported, two of them as endemic (*Anthoceros patagonicus* Häss. subsp. *gremmenii* J.C. Villarreal, J.J. Engel & Váňa, subsp. nov. and *Anthoceros tristanianus* J.C. Villarreal, J.J. Engel & Váňa, sp. nov.). The following short discussion of the occurring liverworts and hornworts on the islands is based predominantly on the publication of Váňa & Engel (2013) and references therein (Wace 1961; Wace & Dickson 1965; Ryan et al. 2007). Hornworts usually grow in large mats in wet and shaded environments, mostly in the lowlands near streams, but *A. patagonicus* is also known from its occurrence on the top of a new volcano (1600 m). The main feature of the hepatic flora is the large number of leafy species which are epiphytic on the trunks of *Blechnum palmiforme* (e.g., *Adelantus lindenbergianus* (Lehm.) Mitt., *Bazzania peruviana* (Nees) Trevis., *Chiloscyphus textilis* (H.f. & T.) J.J. Engel & R.M. Schust., endemic *Ch. wacei* S.W. Arnell ex J.J. Engel et Váňa) and *Phyllica arborea* (e.g., *Chiloscyphus subporosus* (Mitt.) J.J. Engel & R.M. Schust., *Cololejeunea microscopica* (Taylor) Schiffn., the endemics *Plagiochila tristaniana* Váňa & J.J. Engel and *P. wacei* S.W. Arnell ex Váňa & J.J. Engel) in the fern bush vegetation⁴. The liverwort species are most abundant in lowlands, where they seek for damp environments. But they also occur in upland’s mires (e.g., *Anastrophyllum auritum* (Lehm.) Steph., *Chiloscyphus otiphyllus* (H.f. & T.) J.J. Engel & R.M. Schust., *Metahygrobiella tubulata* (H.f. & T.) R.M. Schust., *Perdusenina rheophila* Hässel) and plateau bogs (e.g., *Allisoniella subbipartita* (C. Massal.) R.M.

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⁴ Many of species listed are common in *tree-fern-bush* vegetation and their occurrence on both, *Blechnum* and *Phyllica*, are not an exception.

Schust., *Blepharidophyllum densifolium* (Hook.) Angstr. ex C. Massal., that is nearly restricted to Gough's bogs, than *Cephalozia* species (Dumort.) Dumort., forming dense mats that completely overgrow the *Sphagnum*, *Herbetus sendtneri* (Nees) Lindb., and the bog's dominant *Syzygiella colorata* (Lehm.) Feldberg). More in uplands, hepatics occur on rocks among mosses, for example, *Andrewsianthus marionensis* (S.W. Arnell) Grolle, *Frullania magellanica* F. Weber & Nees subsp. *tristaniana* (S.W. Arnell) Váňa & J.J. Engel (endemic and very common on montane rock), *Plagiochila wacei* and *Syzygiella colorata*), but also on rock slopes such as *Frullania brasiliensis* Raddi and *Metzgeria leptoneura* Spruce. Nevertheless, hepatics are specialized to lowlands and especially to its coastal tussock vegetation (e.g., *Calypogeia annabonensis* Steph., *Cephaloziella* spp. (Spruce) Schiffn., *Chiloscyphus coadunatus*, the endemic *Ch. tristanianus* (S.W. Arnell) J.J. Engel & R.M. Schust., *Telaranea breviseta* (Herzog) J.J. Engel & G.L.S. Merr) and moist or hydric niches (e.g., *Aneura subcanaliculata* R.M. Schust., *Chiloscyphus* spp. Corda; *Dumortiera hirsute* (Sw.) Nees, *Phaeomegaceros plicatus* (Mitt.) J.C. Villarreal). When occurring by the water, they are also found in the Settlement such as *Anthoceros patagonicus*, *Linularia cruciate* (L.) Dumort., *Phaeomegaceros plicatus* and the genus *Marchantia* L., which often seeks for nutrient-rich habitats and is abundant in dense mats in areas with large numbers of seabirds or seals. Some of the most common species of the archipelago are, for example, *Adelantus lindenbergianus*, *Anastrophyllum involutifolium* (Mont. ex Gottsche et al.) Steph., *Bazzania peruviana*, *Chiloscyphus coadunatus* (Sw.) J.J. Engel & R.M. Schust., endemic *Ch. granditextus* Steph., *Ch. serratus* (Mitt.) J.J. Engel & R.M. Schust., *Lepidozia laevifolia* (H.f. & T.) Gottsche et al., and *Syzygiella colorata*.

ALGAE

Another important group among terrestrial non-vascular plants are the limno-terrestrial and freshwater algae (including Cyanobacteria). Although marine algae and seaweeds were collected and reported in past and are known in outline, our knowledge of the non-marine algal flora is limited and still in a preliminary stage (Wace & Dickson 1965; Ryan et al. 2007). In fact, only terrestrial and aquatic diatoms have been intensively collected, identified and published (Carter 1966; Van de Vijver & Kopalová 2008); 173 taxa were reported by Carter (1966), of which 56 as new species whereas one new species was described by Van de Vijver & Kopalová (2008). Additionally, diatoms were listed during paleo-studies that took place on Tristan da Cunha (Holmgren et al. 2011), Inaccessible (Preece et al. 1986) and Nightingale (Holmgren et al. 2013). Nevertheless, only one detailed taxonomic study was done on diatom flora, by John R. Carter who analyzed 12 samples, of which ten were collected during the Royal Society Expedition (in 1962) on Tristan da Cunha and the two remaining were collected from Gough Island during the Gough Island Scientific Survey (in 1956). Furthermore, other collections were recently made by N.J.M. Gremmen, who collected more than 250 samples from Gough Island. Based on material from this collection, so far one new species was described (Van de Vijver & Kopalová 2008), but since then the collection remained virtually unstudied.

Apart from the diatom flora, the following terrestrial algae and Cyanobacteria were reported by Wace & Dickson (1965), Wace (1961) or Váňa & Engel (2013), and here are presented as short listing: i.e., species of *Gloeocapsa* Kützing and *Scytonema* C. Agardh ex Bornet & Flahault, both amongst lichens, *Nostoc* colonies (perhaps *N. fuscescens* F.E. Fritsch) irregularly scattered on the ventral side of hornwort *Anthoceros patagonicus*, *Trentepohlia* spp., which is conspicuous on Gough Island; the rest was collected by J.H. Dickson – species of *Stigeoclonium* (perhaps *S. tenue* Kützing), *Oedogonium* sp. Link ex Hirn, *Spirogyra* sp. Link, *Zygnema* sp. Agardh and *Nostoc* sp. Vaucher, all were gathered from habitat of new lava field near the Settlement (1962), and *Schizothrix cuspidata* W. & G.G. West, which grew by the waterfall).

DIATOMS (BACILLARIOPHYTA)

The study sites studied by Carter (1966) included: rocks in running water at the sea level, salt beach, stones in lowland streams and gulch stream (about 550 m), Crater Lake (1981 m; moss or algal habitat), lowland stream pool, new lava field and other from Gough Island – Cave Bell Rocks at the sea level and lowland stream Gonydale (500 m). The most abundant (in terms of number of species) genera were *Achnanthes*, *Eunotia*, *Navicula*, *Nitzschia*, and *Pinnularia*. The most common taxa in the samples were for example, *Achnanthes lanceolata* (Bréb.) Grun., *A. minutissima* Kütz., *Fragilaria bicapitata* A. May., *F. construens* (Ehr.) Grun., *Gomphonema parvulum* (Kütz.) Grun., *Navicula contenta* Grun., *N. mutica* Kütz., and *Pinnularia subcapitata* Greg., of which only *N. mutica* was found on both islands.

Genera and taxa reported by Carter (1966) are discussed in this paragraph, with respect to localities where they were observed and also with notes from paleo-studies. The salt beach site was inhabited mostly by *Achnanthes* spp., *Fragilaria* spp., *Gomphonema* spp., *Navicula* spp., and *Nitzschia* species, of which some, for example, *Achnanthes natrata* Carter and *Pinnularia tropica* Hust., were not reported from other sites. Interestingly, other species of this site were also quite abundant in cores from the Inaccessible Bog's sites, for example *Eunotia exigua* (Bréb.) Rabh, *Fragilaria brevistriata* Grun. and *Navicula mutica* Kütz. (Preece et al. 1986). Many taxa observed on this site also occur on new lava field (e.g., *Nitzschia petulla* Carter, *Pinnularia biceps* Greg. or *Synedra ulna* (Nitzsch.) Ehr.), and some of *Gomphonema* and *Achnanthes* were also found on stones in running water (sea level). Species found often in streams belonged to the genera *Eunotia*, *Frustulia*, *Gomphonema*, *Melosira* (often on Gough's sites) and *Navicula* (e.g., *Frustulia rhomboides* (Ehr.) de Toni (also reported from the core of 2nd Pond on Nightingale (Holmgren et al. 2013), *Gomphonema parvulum* (Kütz.) Grun. and *Navicula contenta* Grun.). The one discern locality from listed sites above on Tristan da Cunha, is the one of Crater Lake (1981 m), where diatoms were collected from moss and algae. The species found there were often not reported from other sites (e.g., *Achnanthes atalanta* Carter, *Denticula tenuis* Kütz., *Eunotia incurva* Carter, *Navicula gracilis* Carter, *Synedra amphicephala* Kütz.) and some otherwise common genera to Tristan Island are totally absent in samples from this locality (*Gomphonema* spp., *Melosira* spp., *Nitzschia* spp.

and except for two taxa, also *Pinnularia* spp.).

Except for the species *Navicula mutica* (abundant in samples), *Pinnularia dispersa* Carter and three other taxa, Gough Island presents quite a different diatom flora compared to Tristan da Cunha, at least, according to Carter's findings. Above that, results from two paleo-studies (from Tristan, but also from Nightingale Island) did not revealed any shared taxa (Carter 1966; Holmgren et al. 2013; Holmgren et al. 2011). According to the paleobotany study of Preece et al. (1986), four species were reported in common with the remaining island from the archipelago, Inaccessible (*Melosira setosa* Carter, *Orthoseira roseana* (Rabenhorst) O'Meara, *Pinnularia microstauron* (Ehr.) Cl., *Pinnularia restituta* Carter). Nevertheless, a strong correlation can be seen, between those reported from Inaccessible and those from Tristan da Cunha. Noteworthy is, that both studies of diatom material, from Gough and Inaccessible, were made by Carter and described similarly, though the botanical nomenclature and taxonomy used is not up to date with the remaining recent studies. The two studies of Holmgren et al. (2011, 2013) mainly reported diatom species that have not been found on the islands before. Only *P. viridis* (Nitz.) Her (a species typically found in peat bogs) and *Frustulia rhomboides* were also found by Carter on Tristan da Cunha, but otherwise 16 species and five varieties were reported for the first time. A possible explanation is that these new findings were made in a habitat that was not studied so far: stagnant pools (2nd Pond and Bottom Pond), as many new genera for the archipelago were reported, such as for example the meroplanktonic *Aulacoseira*, as well as the terrestrial and aerophytic genera *Diadesmis*, *Luticola* and *Kobayasiella*, together with the benthic genus *Psammothidium* and the epiphytic genus *Chamaepinnularia*. The 2nd Pond on Nightingale was classified as an oligotrophic bog or wetland, with fluctuating water levels throughout most of the Holocene as no planktonic or meroplanktonic taxa were found in the sediment core (Holmgren et al. 2013). Bottom Pond on Tristan da Cunha is a slightly acidic, oligotrophic pond with deep water, dominated by the meroplanktonic genus *Aulacoseira*, e.g., *Aulacoseira alpigena* (Grun.) Krammer and *A. distans* (Ehrenberg) Simonsen (Holmgren et al. 2011).

Although many genera and species, new to the archipelago, were observed, this was not the main objective of these paleolimnological studies. Based on the changes in the diatom flora and the peat content in cores from the ponds of Tristan da Cunha and Nightingale, many of local and some regional events were revealed. The authors identified phases of increased local erosion and precipitation, changes in water level or even suggested dry conditions in the early Holocene. When compared with a multi-proxy study of the environmental changes on Tristan da Cunha, the perhaps most distinct peak of terrestrial diatom concentrations observed by Holmgren et al. (2013) coincides with the 8.2 ka BP cold event in the North Atlantic, as is suggested by Ljung et al. (2006). The comparison of the two studies by Holmgren et al. can also reveal a period of increased precipitation in the Tristan da Cunha region at c. 2200–1700 cal a BP. This is suggested by the authors as an effect of a northward shift of the Southern

hemisphere west wind belt around 2000 cal a BP, thereby placing the Tristan da Cunha archipelago in a more central position affected by more and more intense storms.

4 DISCUSSION

The following discussion presents a synthesis of the known information about each observed plant group, its endemism and world distribution. Total numbers can be seen in the Table 4.1. This includes a total number of taxon present for each plant group, along with a percentage of endemism. Biogeographical position of the Tristan da Cunha archipelago is based on distributional patterns in each discussed plant group.

TABLE 4.1 - Total numbers (taxon level) for each non-vascular plant group + calculated endemism.

	Lichens	Mosses	Liverworts and Hornworts	Diatoms	TOTAL
Number of taxa	125	156	145	232	658
Number of endemic	14	49	18	56	137
% of endemism	11,20	31,41	12,41	24,14	20,82

The geographical relationship of the vegetation on the archipelago is clearly set by conspicuous vascular plants. Tussock grassland is clearly related to the sub-Antarctic insular vegetation, together with *Spartina arundinacea*, structurally similar to the Amsterdam–St. Paul island group. The fern-bush vegetation of *Phyllica arborea* and *Blechnum palmiforme* resembles the communities that can be found in the upper limit of the woody vegetation in tropical mountains, e.g., East African, Jamaican, Tasmanian and New Zealand mountains (the structural equivalent of the typical composition of the archipelagos fern-bush vegetation, is well-present in Wace & Dickson (1965, p. 323)). A strong indication of the closest connection with South America is given by lichens, mosses, liverworts and hornworts, as would be discussed below, to prove the dispersion through prevailing western winds – ‘West Wind Drift’ (see p. 2 of this thesis) (Galloway 1996; Milius 2004; Muñoz et al. 2004). This connection is so strong, that even Skottsberg (1960) had to admit the existence of overseas migration. The existence of long-distance dispersal is also suggested, for example, by the paleobotanical study from Inaccessible Island, which revealed ‘exotic’ taxa such as *Ephedra* and *Nothofagus* in low numbers (Preece et al. 1986). The connection with South America is conspicuous in all groups of non-vascular plants, except for algae of which only diatoms were described, although the actual records are not sufficiently accurate to make proper comparisons. Therefore, diatoms were only compared to some islands across the South Ocean, more as an illustration than as an accurate revision.

LICHENS

The level of endemism in the lichen flora of the archipelago is not clear. It is generally surprisingly lower than on islands elsewhere, as stated by Jørgensen (1977), about 5 % of the island species are

endemic. However, thenceforward some new representatives were discovered, and this movement may continue in future research. Accepting the newly discovered species as endemics and with the total number of species from Appendix 7.1 (125), this brings the endemic level up to 11,2 %. Nevertheless, only time and further collecting will show, because some of them are supposed to be easily dispersing (e.g., the sorediate *Caloplaca austroatlantica* Øvstedal). In general, lichens seem more widespread than other plants and show less tendency to form local endemism, but they're also especially vulnerable to air condition, though repeated volcanisms may have destroyed the lichens more than other plant groups (Jørgensen 1977). From the records mentioned, the resemblance between the Gough and Tristan group based on lichens is undeniable (Jørgensen 1977, 1979; Elix & Gremmen 2002) but this can be also disproved by other newly described species, as Øvstedal & Gremmen (2010) already added a few (4 to Tristan and 3 to Gough). In addition to, clear affinities are visible to South America (Jørgensen 1979; Elix & Gremmen 2002) as can be seen in the genera *Cladonia* and *Stereocaulon*, as well as on some typical species *Punctelia canaliculata*, *Hypotrachyna bogotensis* and *H. microblasta*. Only a few species have not been recorded there yet (e.g., *Dirinaria applanata*, *Heterodermia casarettiana*, *Stereocaulon meyeri* Stein and *Physcia erosula* Nyl.) and beyond that, quite a number are restricted to the archipelago and the Magellanic region of the southernmost South America, which is also supported by other plant groups (Jørgensen 1979). As is mentioned above, west winds works well in distribution of lichens, from South America to the Tristan da Cunha archipelago. The example of wind-connection can also be seen on the Bouvet Island on one side, and Ile Amsterdam and St. Paul on the other. The sub-Antarctic Bouvet Island, which is only some 1,860 km away from Gough Island, shares no lichens (Muñoz et al. 2004); but Gough has approximately 18 lichen species (or even more) in common with the 7,400 km distant Amsterdam–St. Paul island group (based on Appendix 7.1 and Aptroot et al. 2011). Obviously not the distance, but being right on the West Wind Drift (and not interrupted by any continent, as Africa is northerly) can provide distant islands with common species that are not necessarily are only lichenous. The lichen species recorded, range in origin from tropical (often mountainous places) across subtropical (eg *Dirinaria applanata*, *Pyxine* cf. *cocoës*) to temperate (Elix & Gremmen 2002), with only the rare exception of *Stereocaulon vesuvianum* that reaches the Arctic (see above).

MOSSES

The level of endemism in the moss flora of the archipelago is currently unknown. According to Dixon (1960) the number of endemic species is larger than actually accepted. He reported 128 species from which 59 were endemics to the islands (46 % of the native flora). This was marked by Jørgensen (1979) who studied lichens, as 'an alarmingly higher percentage of endemism'. Likewise, in Wace & Dickson (1965), the level of endemism was estimated at 43 % for the mosses. This shows that the level of moss's endemism is higher than in other plant groups, to which probably only pteridophytes can compete. After the revision of reported species, with the total number of species from Appendix 7.2

(156), the level of endemism now is close to 32 %. This supports Dixon's (1960) opinion that a certain number of the endemic species may be discovered elsewhere later, but it is difficult to say since no new records are out.

Although mosses can easily spread through spores, vegetative structures, or even can regenerate from tiny broken-off pieces, many of them have a very limited range (Frahm 2007; Milius 2004). The Tristan da Cunha archipelago reflects some distributional patterns on the composition of moss species. The connection of Tristan group and further Gough Island is obvious, they share many *Hypnum* spp., *Dicranoloma* spp., *Pohlia* spp. and *Campylopus* species, and also some endemics (*Macromitrium antarcticum*, *Philonotis capillata* Mitt., *Pohlia excurrens*, *Rhynchostegium isopterygioides*). As well as in lichen species, the connectivity throughout the 'West Wind Drift' is clearly visible. This supports a prevalent number of species common to the archipelago and to the southernmost South America (Dixon 1960; Ochyra 1999) for example, *Andreaea grimmioides*, *Brachythecium austroglareosum* (Müll. Hal.) Kindb., *Bartramia patens*, *Dicranella fuegiana* Card. & Broth, *Dicranoloma* spp., *Philonotis vagans*, *Racomitrium* spp. Another statement of Dixon (1960) was that a clear evidence of connection with the South African flora is absent, but for example *Dicranella hookeri* (C.M.) Card. (a pan-south-temperate species) was recently recorded in South Africa (Ochyra et al. 2013). This and also some others (e.g., *Chrysoblastella chilensis*) can present the progressive spread of species from the West. Nevertheless, some 14 species are of almost cosmopolitan range; worth to mention that apart from them, no species of Palearctic or Holarctic distribution is known from the islands (Dixon 1960). Also no record of moss introduction by human to the archipelago is known, apart from one of *Pseudoscleropodium purum* (Limpr.) Fleisch., which was used as packing material and arrived from St. Helena (Dickson 1967).

LIVERWORTS AND HORNWORTS

The level of specific endemism in the Liverworts and Hornworts flora has been estimated by Wace & Dickson (1965) to 14 % of the total flora. Váňa & Engel (2013), after their comprehensive study, reduced this number slightly, to 18 taxa and 12,41 % respectively. But they also described two new genera, five species and two intraspecific taxa, in total nine new combinations.

Among liverworts and hornworts, Váňa & Engel (2013) recognized 145 taxa present on the Tristan da Cunha archipelago. This indicates a great revision of the species reported earlier, as both Wace & Dickson (1965) and Ryan (2007) stated more (160, and some 165); although, still some doubtful records are indicated which should be verified more in future (Váňa & Engel 2013). The species present on the archipelago show some distributional patterns which partly also reflect patterns of lichens and mosses. The strongest correlation of liverworts and hornworts flora of the Tristan da Cunha archipelago is some 37,93 % shared taxa with 'temperate regions of South America'. This means the Magellanian region (but without Tierra del Fuego), Valdivian region, a combination of both and the Andes. As follows, every region is listed with its representatives in brackets: Magellanian region (*Chiloscyphus patulistipus*

(Steph.) J.J. Engel & R.M. Schust., *Perdusenina rheophila* Hässel; 10 taxa in total), Valdivian region (*Metzgeria epiphylla* A. Evans; 13 taxa) and a combination of both (*Ch. textilis*, *Kurzia saddlensis* (B. & C. M.) Grolle; 26 taxa), also the Andes (*Microlejeunea bullata* (Taylor) Steph.; 6 taxa). Among the regions listed are also distributed some taxa from: Juan Fernández Island (*Bazzania peruviana*, *Riccardia tristaniana* S.W. Arnell; 42 taxa), Falkland Island (*Leptoscyphus aequatus* (H.f. & T.) Mitt.) and South Georgia. Interesting is the correlation between the Tristan Group and Juan Fernández Is. with 29 % of common taxa; Valdebenito et al. (1990) also well documented this connection on the inter-population disjunction for *Peperomia* (Piperaceae). Other noteworthy phytogeographical patterns are those of Amphiatlantic temperate (7,58 %), Amphipacific temperate (5,52 %), Sub-Antarctic (5,52 %), and Tropical (11,04 %; including tropical taxa from America, Africa, Paleotropical and Pantropical). On the other hand, not many are restricted (2 %) to the Australasia region (New Zealand + Tasmania), only three taxa with Oceania (absent from the sub-Antarctic islands), two taxa are of Bipolar distribution, and also the correlation with Ile Amsterdam–St. Paul group of islands is not strong. The archipelago has some 11 species in common with Ile Amsterdam (10) and St. Paul (1), mostly with an Amphiatlantic, Amphipacific (*Lepidozia laevifolia*) or Pan–South Temperate (*Anastrophyllum auritum*) distribution (Váňa et al. 2010; Váňa & Engel 2013), and no uniquely shared species, but not many records can be found on this plant group from this South Indian Ocean island group.

DIATOMS

The samples studied by Carter (1966) from Tristan da Cunha Island and Gough Island, revealed 56 new species which were described by the author. On Gough respectively, genera with most species are *Melosira*, *Navicula* and *Pinnularia*; note that many of them were newly described by Carter. The author found a very distinct and highly specific diatom flora on Gough Island, with many new species (as 24 of all newly described species were from Gough) that so far haven't been reported from elsewhere (Van de Vijver & Kopalová 2008). From the other studies dealing with diatoms it is clear that the diatom flora is particularly diverse on the archipelago, with 203 species (plus another 29 forms and varieties) in 38 genera present. This number of species is an expected one, based on the diversity on other Southern Ocean islands (Ryan et al. 2007). However, the majority of species is reported from localities of the Tristan Group, leaving only 42 species reported from Gough Island, 41 by Carter (1966) plus *Orthoseira gremenii* (Van de Vijver & Kopalová 2008). Out of this, only 12 species are shared between Gough and Tristan Group. The level of endemism is certainly not clear for diatoms, only the above-mentioned publications revealed new species to the archipelago, and these by Carter (1966) are not easily understood because all of them were only illustrated by one or a few small drawings (Kopalová et al. 2008). Accordingly, the level of endemism shown in Table 4.1 (at the beginning of the Discussion, p. 22) has to be taken with some respect.

The diatom taxa observed in Bottom Pond (Tristan da Cunha) seem to have a high correlation to

taxa in the sub-Antarctic areas (Ile de la Possession, Prince Edward Islands, Marion Island) including both cosmopolitan and southern hemisphere taxa (Holmgren et al. 2011; Van de Vijver & Beyens 1999). A comparison between other islands revealed low similarity values. I compared the Tristan Island Group (Tristan da Cunha, Nightingale and Inaccessible Island together) and Gough Island with sub-Antarctic Marion and Prince Edward Island (Van de Vijver, Gremmen, et al. 2008), Ile Amsterdam in South Indian Ocean (Chattová et al. 2014; Lowe et al. 2013) and with James Ross and Livingston Island from Maritime Antarctica (Kopalová et al. 2014). The results of taxa they have in common are summarized below, in Table 4.2.

Table 4.2 - Number of taxa in common; the Tristan da Cunha Island Group and Gough Island compared with selected localities in South Atlantic and South Indian Ocean.

	Marion + Prince Edward Island	Ile Amsterdam	James Ross + Livingston Island
Tristan Island Group	26	13	9
Gough Island	2	1	1
Tristan Island Group + Gough Island	1	2	0
Tristan da Cunha archipelago	29	16	10

Generally, most of the species shared by these localities are of cosmopolitan range. Many taxa shared are not reported by Carter (e.g., *Diadasmus ingae* Van de Vijver, *Luticola muticopsis* (Van Heurck) Mann), except for taxa from Ile Amsterdam (Chattová et al. 2014; Lowe et al. 2013; Carter 1966). Among those belongs for example, *Gomphonema parvulum* (Kütz.) Grun., *Nitzschia frustulum* (Kütz.) Grun. or *Pinnularia microstauron* (Ehr.) Cl. Other noteworthy genera in common with Ile Amsterdam are *Melosira*, *Gomphonema*, *Navicula* and *Nitzschia*, with the composition of species closer to Gough Island. Many of species are similar with Prince Edward Islands – for example, *Caloneis bacillum* (Grun.) Mereschk., *Diadasmus langebertalotii* Le Cohu & Van de Vijver, *Frustulia vulgaris* Thw., *Melosira varians* Agdh. or *Pinnularia intermedia* Lagerstedt (Van de Vijver, Gremmen, et al. 2008). Only some are similar to Maritime Antarctic region, but genera such as *Diadasmus* (e.g., *Diadasmus contenta* (Grun.) Mann) or *Luticola* can be found (Kopalová et al. 2012, 2014).

The distribution of micro-organisms, such as algae, is presently the subject of a lively debate. Accordingly to diatoms, with the ‘Ubiquity theory’ on one side (Finlay 2002) and ‘Biogeography theory’ on the other (Vyverman et al. 2007). The first view is that micro-organisms have unrestricted dispersal capacities, thus could be everywhere as cosmopolitans, the other one is that at least some of them, such as diatoms, has dispersal limited and can be also endemic. The Tristan da Cunha archipelago, with so many species newly described by John R. Carter, and also with the recent collection, has a potential to add a significant piece in this puzzle.

5 CONCLUSION

This thesis focuses on the non-marine non-vascular plants from the archipelago Tristan da Cunha located in the South Atlantic Ocean. Despite its very interesting geographical position, its oceanic origin and number of interesting habitats, most of the non-vascular flora of the archipelago is only limitedly known.

However, out of this is a plant group of Liverworts and Hornworts, with its recent comprehensive publication of Váňa & Engel (2013). The authors determined large amount of specimens from recent collections of N. Gremmen and several others, which led to the examination of a great majority of collections made in the archipelago before. This collection of N.J.M. Gremmen also allowed identifying many new species of lichens, which are the other quite well-known group, but with no comprehensive study or revision of earlier reported species. Although mosses are conspicuous plants on the islands, forming bogs or mountain habitats, only few publications of its flora can be found. Maybe a new collection, but certainly a proper revision of the moss flora is well-needed as the current list of known species is quite confusing due to a lot of synonymous and taxonomical updates and even errors (Frahm 2007). Group of non-marine algae is certainly the most understudied at all. Except for diatoms, only a few lines can be told about the algal group. Although some comparison could be made on the diatom data from the Tristan da Cunha archipelago, the validity of these comparisons is questionable. Only a revision of species described by Carter (1966) including a reanalysis of these using modern light and scanning electron microscopy would enable other work with diatoms. Furthermore, the results of this reanalysis might be then used to study the diatom diversity in a set of more than 250 recently collected samples from Gough Island. This would allow a biogeographical comparison between Gough Island and other localities in the Southern hemisphere, which is well-needed in the light of ongoing research on the biogeography of diatoms related to questions about Ubiquity theory. Hopefully, this will be a challenge for my master thesis next year.

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7 APPENDICES

APPENDIX 7.1 - List of 125 lichen taxa reported from the Tristan da Cunha archipelago.

NOTE: * endemic; **endemic to Tristan da Cunha and St. Helena. Distribution within the archipelago: T – Tristan da Cunha Island, N – Nightingale Is., I – Inaccessible Is., S – Stoltenhoff Is., G – Gough Is., M – Middle (Alex) Is.

TAXON NAME	DISTRIBUTION
<i>*Buellia acunhana</i> (Nyl.) Zahlbr. - Wace & Dickson (1965: 353)	
<i>*Caloplaca austroatlantica</i> Øvstedal sp. nov. - Øvstedal & Gremmen (2010: 44)	T
<i>Cladonia balfourii</i> Cromb. - des Abbayes (1940: 4), Wace & Dickson (1965: 353)	
<i>C. capitellata</i> (Tayl.) Bab. f. - des Abbayes (1940: 3), Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. ceratophylla</i> (Sw.) Spreng. - des Abbayes (1940: 3), Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. coccifera</i> Willd. - Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. coccifera</i> var. <i>aberrans</i> des Abb. - des Abbayes (1940: 1)	
<i>C. didyma</i> (Fèe) Vain. - Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. didyma</i> var. <i>vulcanica</i> f. <i>minor</i> - des Abbayes (1940: 2)	
<i>C. fallax</i> f. <i>condensata</i> - des Abbayes (1940: 1)	
<i>C. gracilis</i> (L.) Willd. - Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. gracilis</i> var. <i>chordalis</i> - des Abbayes (1940: 3)	
<i>C. chlorophaea</i> (Flörke ex Sommerf.) Spreng. - des Abbayes (1940: 4 as <i>C. pyxidata</i> var. <i>chlorophaea</i>)	
<i>C. laevigata</i> (Wain.) Gyeln. - Wace & Dickson (1965: 353 as <i>Cladonia mitis</i>), Jørgensen (1977: 11)	
<i>C. macilenta</i> Nyl. - Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. macilenta</i> var. <i>styracella</i> - des Abbayes (1940: 3)	
<i>C. mitis</i> f. <i>laevata</i> - des Abbayes (1940: 1)	
<i>C. ochrochlora</i> - des Abbayes (1940: 4), Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. pityrea</i> (Flk.) Fr. - Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. pycnoclada</i> (Pers.) Nyl. - Jørgensen (1979: 2281); as <i>Cladonia fallax</i> - des Abbayes (1940: 1), Wace & Dickson (1965: 353)	
<i>C. pyxidata</i> (L.) Fr. - Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. pyxidata</i> var. <i>neglecta</i> - des Abbayes (1940: 4)	
<i>C. scabriuscula</i> (Del.) Sandst. - Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>C. squamosa</i> Hoffm. - Christophersen (1934: 13), Wace & Dickson (1965: 353)	G
<i>*Cresponea soredata</i> Elix, Øvstedal & Gremmen, sp. nov. - Elix, Øvstedal & Gremmen (2011: 134)	G
<i>Dirinaria applanata</i> (Fée) Awasthi - Jørgensen (1977: 11), Jørgensen (1979: 2281)	N,I,M
<i>Erioderma groenalianum</i> (Ach.) Wain. - Jørgensen (1977: 12), Jørgensen (1979: 2281)	I
<i>*Gyalidea goughensis</i> Øvstedal sp. nov. - Øvstedal & Gremmen (2010: 44)	G
<i>Heterodermia casarettiana</i> (Mass.) Trevis. - Jørgensen (1977: 10 as <i>Anaptychia casarettiana</i>), Jørgensen (1979: 2281)	N
<i>H. leucomela</i> (L.) Poelt - Jørgensen (1977: 10 as <i>Anaptychia leucomela</i>), Jørgensen (1979: 2281)	N
<i>H. speciosa</i> (Wulf.) Trevis. - Jørgensen (1977: 10 as <i>Anaptychia speciosa</i>), Jørgensen (1979: 2281)	I
<i>Hypotrachyna bogotensis</i> (Vain.) Hale - Elix & Gremmen (2002: 259)	G
<i>H. endochlora</i> (Leight.) Hale - Elix & Gremmen (2002: 260); as <i>Parmelia endochlora</i> - Jørgensen (1977: 15), Jørgensen (1979: 2281)	G, N, I
<i>H. gondylophora</i> (Hale) Hale - Ryan et al. (2007: 59)	
<i>H. microblasta</i> (Vain.) Hale - Elix & Gremmen (2002: 260); as <i>Parmelia microblasta</i> Wain. - Jørgensen (1977: 16), Jørgensen (1979: 2281)	G, T, I
<i>H. revoluta</i> Flörke - as <i>Parmelia revoluta</i> - Wace & Dickson (1965: 353), Jørgensen (1977: 17), Jørgensen (1979: 2281)	I
<i>Lecanora subfusca</i> Ach. - Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>*Lepraria goughensis</i> Elix & Øvstedal, sp.nov. - Elix, Øvstedal & Gremmen (2005: 274)	G

APPENDIX 7.1 – (continued)

TAXON NAME	DISTRIBUTION
<i>Leptogium</i> cf. <i>azureum</i> (Ach.) Mont. (Syn. <i>L. tremelloides</i>) - Jørgensen (1977: 12), Jørgensen (1979: 2281)	I
<i>L. brebissonii</i> Mont. - Jørgensen (1977: 13), Jørgensen (1979: 2281)	T,I
<i>L. denticulatum</i> auct. non. Nyl. - Jørgensen (1977: 13)	T,I
<i>L. laceroides</i> B. de Lesd. - Jørgensen (1977: 14), Jørgensen (1979: 2281)	I
* <i>Massalongia griseolobulata</i> Øvstedal sp. nov. - Øvstedal & Gremmen (2010: 45)	G
<i>Normandina pulchella</i> (Borr.) Nyl. - Jørgensen (1979: 2281)	
<i>Parmelia cetrata</i> Ach. Coll. - Christophersen (1934: 13), Wace & Dickson (1965: 353), Jørgensen (1977: 14), Jørgensen (1979: 2281)	T,N,S,G
<i>P. dilatata</i> Wain. coll. - Jørgensen (1977: 15), Jørgensen (1979: 2281)	N
<i>P. dissecta</i> Nyl. - Jørgensen (1977: 15), Jørgensen (1979: 2281)	N,S
<i>P. formosana</i> Zahlbr. coll. - Jørgensen (1977: 16), Jørgensen (1979: 2281)	N
<i>P. maura</i> Pers. (Syn. <i>P. reticulata</i>) - Jørgensen (1977: 16), Jørgensen (1979: 2281)	T,N,I
<i>P. microspora</i> Müll. Arg. - Jørgensen (1977: 16), Jørgensen (1979: 2281)	T,N
<i>P. reddenda</i> Stirt. - Jørgensen (1977: 17), Jørgensen (1979: 2281)	S
** <i>P. revolutella</i> Nyl. - Wace & Dickson (1965: 353), Jørgensen (1977: 18), Jørgensen (1979: 2281)	T,S
<i>P. rockii</i> Zahlbr. - Jørgensen (1977: 18), Jørgensen (1979: 2281)	N
<i>P. rudecta</i> Ach. - Jørgensen (1977: 18), Jørgensen (1979: 2281)	N
<i>P. saxatilis</i> (L.) Ach. - Christophersen (1934: 13), Wace & Dickson (1965: 353)	G
<i>P. sphaerosporella</i> Müll. (syn. <i>Ahtiana sphaerosporella</i>) - Christophersen (1934: 13), Wace & Dickson (1965: 353)	G
<i>Parmeliella nigrocincta</i> (Mont.) Müll. Arg. - Jørgensen (1977: 18), Jørgensen (1979: 2281)	T
<i>P. parvula</i> P. M. Jørg. N. sp. - Jørgensen (1977: 19), Jørgensen (1979: 2281)	I
<i>P. pycnophora</i> (Nyl.) R. Sant. - Jørgensen (1977: 20), Jørgensen (1979: 2281)	T,I
<i>Parmelinopsis afrorevoluta</i> (Krog & Swinsc.) Elix & Hale - Elix & Gremmen (2002: 260)	G
<i>Parmotrema arnoldii</i> (Du Rietz) Hale - Elix & Gremmen (2002: 261)	G
<i>P. crinitum</i> (Ach.) M. Choisy - Elix & Gremmen (2002: 261); as <i>Parmelia crinita</i> - Jørgensen (1977: 15), Jørgensen (1979: 2281); as <i>Parmelia proboscidea</i> in Wace & Dickson (1965: 353)	G,T,N,S
<i>P. gardneri</i> (C. W. Dodge) Sérus. - Elix & Gremmen (2002: 261)	G
<i>P. perforatum</i> (Wulf.) xxx - Wace & Dickson (1965: 353)	
<i>P. perlatum</i> (Huds.) Ach. - Wace & Dickson (1965: 353); as <i>Parmelia perlata</i> (Huds.) Ach. - Jørgensen (1977: 17), Jørgensen (1979: 2281)	T,N,I
<i>P. reticulatum</i> (Taylor) M.Choisy - Elix & Gremmen (2002: 262 as <i>Rimelia reticulata</i>)	G
<i>Peltigera dolichorhiza</i> Nyl. - Jørgensen (1977: 20), Jørgensen (1979: 2281)	T,I
<i>P. friesiorum</i> Gyeln. - Jørgensen (1977: 20), Jørgensen (1979: 2281)	T
<i>P. polydactyla</i> (L.) Hoffm. - Wace & Dickson (1965: 354)	
<i>Physcia erosula</i> Nyl. - Jørgensen (1977: 21), Jørgensen (1979: 2281)	I
<i>P. stellaris</i> Nyl. - Christophersen (1934: 13), Wace & Dickson (1965: 353)	G
<i>P. tribacioides</i> Nyl. (syn. <i>P. sorediata</i>) - Jørgensen (1977: 21), Jørgensen (1979: 2281)	
<i>Physciopsis adglutinata</i> (Flk.) Choisy - Jørgensen (1977: 22), Jørgensen (1979: 2281)	N
<i>Placopsis cribellans</i> (Nyl.) M. Lamb - Lamb (1940: 1), Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	T
<i>P. fuscidula</i> M. Lamb - Lamb (1940: 1), Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	T
<i>P. gelida</i> (L.) Linds. - Lamb (1940: 2), Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	T
<i>P. parellina</i> (Nyl.) M. Lamb - Lamb (1940: 3), Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	
<i>P. parellina</i> var. <i>carnea</i> (Räs.) M. Lamb - Lamb (1940: 3)	I
<i>P. parellina</i> var. <i>rhodocarpa</i> (Nyl.) M. Lamb - Lamb (1940: 3)	T
<i>P. perrugosa</i> (Nyl.) - Lamb (1940: 4), Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	T

APPENDIX 7.1 – (continued)

TAXON NAME	DISTRIBUTION
<i>P. rhodophalma</i> (Müll. Arg.) Räs. - Lamb (1940: 4), Wace & Dickson (1965: 353), Jørgensen (1979: 2281)	T
<i>Polychidium dendriscum</i> (Nyl.) A. Henssen - Jørgensen (1977: 22), Jørgensen (1979: 2281)	T,I
<i>Pseudocyphellaria aurata</i> Vain. - Wace & Dickson (1965:353), Jørgensen (1977:22), Jørgensen (1979:2281), Ryan(2007:59)	T,N,I
<i>P. gilva</i> (Ach.) Malme - Jørgensen (1977: 23), Jørgensen (1979: 2281)	T
<i>P. intricata</i> (Del.) Vain. (syn. <i>P. thouarsii</i>) - Wace & Dickson (1965: 354), Jørgensen (1977: 23), Jørgensen (1979: 2281)	T,I
<i>Psoroma hypnorum</i> (Vahl) S. F. Gray var. <i>paleaceum</i> (Fr.) Rostr. - Jørgensen (1977: 24), Jørgensen (1979: 2281)	T
<i>Punctelia canaliculata</i> (Lynge) Krog - Elix & Gremmen (2002: 262)	G
<i>Pyxine</i> cf. <i>cocoës</i> (Sw.) Nyl. - Jørgensen (1977: 24), Jørgensen (1979: 2281)	I
<i>Ramalina celastri</i> (Spreng.) Krog & Swinscow (syn. <i>R. ecklonii</i>) - Jørgensen (1977: 24), Jørgensen (1979: 2281)	N
*R. elegantula P. M. Jørg. - Jørgensen (1977: 25), Jørgensen (1979: 2281)	I
<i>R. cf. laevigata</i> Fr. - Jørgensen (1977: 26), Jørgensen (1979: 2281)	N,S
<i>R. peruviana</i> Ach. coll. - Jørgensen (1977: 26), Jørgensen (1979: 2281)	N
<i>R. cf. linearis</i> (Sw.) Ach. - Jørgensen (1977: 26), Jørgensen (1979: 2281)	T
<i>R. intermedia</i> Del. - Wace & Dickson (1965: 354)	I
<i>R. scopulorum</i> Ach. (Syn. <i>R. siliquosa</i>) - Christophersen (1934: 13), Wace & Dickson (1965: 354)	G
<i>R. tayloriana</i> Zahlbr. - Jørgensen (1977: 27), Jørgensen (1979: 2281)	N
<i>R. yemenensis</i> (Ach.) Nyl. - Wace & Dickson (1965: 354)	I
<i>Stereocaulon antarcticum</i> Vain. - Wace & Dickson (1965: 354)	
<i>S. atlanticum</i> - Ryan et al. (2007: 59)	
<i>S. corticatulum</i> Nyl. - Jørgensen (1977: 27), Jørgensen (1979: 2281)	T,I
<i>S. glabrum</i> (Müll. Arg.) Wain. - Jørgensen (1977: 28), Jørgensen (1979: 2281)	T
<i>S. implexum</i> Th. Fr. - Wace & Dickson (1965: 354), Jørgensen (1977: 28), Jørgensen (1979: 2281)	T
<i>S. meyeri</i> Stein - Jørgensen (1977: 29), Jørgensen (1979: 2281)	T,I
<i>S. ramulosum</i> (Sw.) Rausch. - Wace & Dickson (1965: 354 as <i>S. mixtum</i>)	
<i>S. cf. myriocarpum</i> Th. Fr. - Jørgensen (1977: 29), Jørgensen (1979: 2281)	T
<i>S. vesuvianum</i> Pers. - Jørgensen (1979: 2281)	T
<i>Stictia ambavillaria</i> (Bory) Ach. - Wace & Dickson (1965: 354), Jørgensen (1977: 30), Jørgensen (1979: 2281)	T,I
<i>S. fuliginosa</i> Nyl. (Dicks.) Ach. - Christophersen (1934: 13), Wace & Dickson (1965: 354), Jørgensen (1977: 30), Jørgensen (1979: 2281)	I,G
<i>S. limbata</i> (Sm.) Ach. - Jørgensen (1977: 30), Jørgensen (1979: 2281)	I
*S. tessellata Øvstedal sp. nov. - Øvstedal & Gremmen (2010: 46)	G
*Szcawinskia phyllicae Øvstedal sp. nov. - Øvstedal & Gremmen (2010: 47)	T
<i>Teloschistes flavicans</i> (Ew.) Norm. - Wace & Dickson (1965: 354), Jørgensen (1977: 30), Jørgensen (1979: 2281), Ryan et al. (2007: 59)	N,I
<i>Tephromela atra</i> - Ryan et al. (2007: 59)	
*Tephromela rimosula Øvstedal sp. nov. - Øvstedal & Gremmen (2010: 47)	T
<i>T. lepabinum</i> (Ach.) Ach. - Jørgensen (1979: 2281)	
*T. tristanense Øvstedal sp. nov. - Øvstedal & Gremmen (2010: 48)	T
<i>Usnea articulata</i> Hoffm. - Wace & Dickson (1965: 354)	
<i>U. barbata</i> (L.) Wigg. em. Mot. - Christophersen (1934: 13), Wace & Dickson (1965: 354)	G
<i>U. ceratina</i> Ach. - Jørgensen (1977: 31), Jørgensen (1979: 2281), Wace & Dickson (1965: 354 as <i>U. plicata</i>)	T,N
<i>U. dasycera</i> (Nyl.) Mot. - Jørgensen (1977: 32)	T,N,I
*U. nigropapillosa P. M. Jørg. N. sp. - Jørgensen (1977: 32), Jørgensen (1979: 2281)	N,S

APPENDIX 7.1 – (continued)

TAXON NAME	DISTRIBUTION
<i>U. rubicunda</i> Stirt.coll. - Jørgensen (1979: 2281), Wace & Dickson (1965: 354 as <i>U.rubigena</i>)	
<i>U. strigosa</i> subsp. <i>rubiginea</i> (Michaux) I. Tav. - Jørgensen (1977: 34 as <i>U. rubiginea</i>)	N
* <i>U. vermicularis</i> P. M. Jørg. - Jørgensen (1977: 35), Jørgensen (1979: 2281)	I
<i>Verrucaria durietzii</i> I.M. Lamb - Ryan et al. (2007: 59)	

APPENDIX 7.2 - List of 156 moss taxa reported from the Tristan da Cunha archipelago.

NOTE: * Endemic; ? Doubtful records. Distribution within the archipelago: T – Tristan da Cunha Island, N – Nightingale Island, I – Inaccessible Island, G – Gough Island.

TAXON NAME	DISTRIBUTION
* <i>Amblystegium patenti-flexuosum</i> Dixon - Dixon (1960: 41)	I
* <i>A. stricto-serpens</i> Dixon - Dixon (1960: 40)	T
* <i>Andreaea atlantica</i> Dixon - Dixon (1960: 9)	T
<i>A. grimmoides</i> Dus. - Dixon (1960: 8)	T
<i>A. nitida</i> var. <i>aquatica</i> (R. Br. bis) W. Martin - Dixon (1960: 9 as <i>Andreaea aquatica</i>)	T
<i>A. parallela</i> C. M. - Dixon (1960: 9); Wace & Dickson (1965: 342)	
<i>A. regularis</i> C. M. - Dixon (1960: 9)	T
<i>A. rupestris</i> Hedw. - Wace & Dickson (1965: 342 as <i>A. loricata</i> Dus.)	G
* <i>A. squarriifolia</i> Dixon - Dixon (1960: 10)	T
<i>Androcryphia confluens</i> - Bartram (1959: 210)	G
<i>Anomobryum julaceum</i> W. P. Schimper - Dixon (1960: 30 as <i>A. filiforme</i>)	T
* <i>Bartramia inconspicua</i> Mitt. - Dixon (1960: 7)	T
<i>B. ithyphylla</i> Brid. - Dixon (1960: 35 as <i>B. stenobasis</i> Card.) Ochyra (1999: 515)	T,G
* <i>B. obscura</i> Dixon - Dixon (1960: 35)	T
<i>B. patens</i> Brid. - Dixon (1960: 35)	T,I
<i>B. robusta</i> H. f. & W. - Dixon (1960: 7 as <i>B. radicata</i> Mitt.)	T
<i>Bazzania skottsbergii</i> (St.) Fulford. - Bartram (1959: 210)	G
* <i>Blindia brachystegia</i> Dixon - Dixon (1960: 14)	T
* <i>B. subcapillifolia</i> Dixon - Dixon (1960: 14)	T
<i>Brachymenium megalacrion</i> (Schwägr.) Jaeg. - Wace & Dickson (1965: 344)	
<i>Brachythecium austroglareosum</i> (Müll. Hal.) Kindb. - Ochyra (1999: 514); as <i>Brachythecium subpilosum</i> (H. f. & W.) Jaeg. - Bartram (1959: 210), Dixon (1960: 43); Wace & Dickson (1965: 345 as <i>Brachythecium pallidoflavens</i> Card.)	T,G
<i>Brachythecium subplicatum</i> (Hampe) Jaeg. - Wace & Dickson (1965: 345)	G
<i>Braunia humboldtii</i> (Hook.) Hook. f. - Wace & Dickson (1965: 345 as <i>Rhacocarpus humboldtii</i> (Hook.) Lindb.)	G
? <i>Breutelia dumosa</i> Mitt. - Christophersen (1934: 10); Wace & Dickson (1965: 344)	G
<i>B. integrifolia</i> (Tayl.) Jaeg. - Dixon (1960: 37)	T
<i>B. popinqua</i> Kaal. - Dixon (1960: 37)	T,I
* <i>B. tenuifolia</i> (Mitt.) Par. - Dixon (1960: 37); Bartram (1959: 210)	T,I,G
* <i>Bryum amplifolium</i> Dixon - Dixon (1960: 31)	T
* <i>B. cymbifoliellum</i> Dixon - Dixon (1960: 32)	T
* <i>B. flaccidifolium</i> Dixon - Dixon (1960: 6)	T
? * <i>B. fluitans</i> Dixon - Dixon (1960: 33)	I

APPENDIX 7.2 – (continued)

TAXON NAME	DISTRIBUTION
<i>B. laevigatum</i> H. f. & W. - Dixon (1960: 33 as <i>B. incurvifolium</i>)	T
* <i>B. subantarcticum</i> Dixon - Dixon (1960: 33)	T,I
* <i>B. subulinerve</i> Card. - Dixon (1960: 33)	I,G
* <i>B. tenellicaule</i> Card. - Dixon (1960: 31); Bartram (1959: 210)	T,I,G
* <i>B. tristaniense</i> Dixon - Dixon (1960: 30)	T
? <i>B. truncorum</i> Brid. - Dixon (1960: 34)	T,I,N
? <i>Campylium polygamum</i> (Bry. Eur.) Bryhn - Dixon (1960: 42)	T
* <i>Campylopus alienus</i> Dixon - Dixon (1960: 19)	T,I,N
<i>C. arcuatus</i> Mitt. - Wace & Dickson (1965: 343)	T
<i>C. pyriformis</i> (Schultz) Brid. - Dixon (1960: 19 as <i>C. calvatus</i> ; 20 as <i>C. luscinialis</i>)	T,I,N
<i>C. incrassatus</i> Müll. Hal. - Wace & Dickson (1965: 343 as <i>C. alvarezianus</i> Card.)	G
<i>C. introflexus</i> (Hedw.) Brid. - Dixon (1960: 19)	T,I,N
<i>C. vesticaulis</i> Mitt. (Syn. <i>C. saddleanus</i>) - Dixon (1960: 18); Bartram (1959: 209)	T,G,N
<i>C. richardii</i> Brid. - Wace & Dickson (1965: 343 as <i>Thysanomitrium richardii</i> Schwaegr.)	G
<i>Catagonium nitidum</i> (H. f. & W.) Broth. - Dixon (1960: 45)	T
<i>Chorisodontium aciphyllum</i> (Hook. f. & Wilson) Broth. - Dixon (1960: 18 as <i>Dicranum aciphyllum</i> H. f. & W.)	T,I
<i>Chrysoblastella chilensis</i> (Mont.) Reimers - Dixon (1960: 16 as <i>Dichodontium opacifolium</i> Dixon)	T
* <i>Ceratodon plano-marginatus</i> Dixon - Dixon (1960: 13)	N
<i>C. purpureus</i> (Hedw.) Brid. - Dixon (1960: 23 as <i>Barbula validinervia</i> C. M.)	T,N
<i>Cratoneuron</i> sp. - Dixon (1960: 42)	T
<i>Cyclodictyon laete-virens</i> (Hook. & Tayl.) Mitt. - Dixon (1960: 39)	T,I,G
* <i>Daltonia tristaniensis</i> Dixon - Dixon (1960: 39)	T,G
<i>Dicranella fuegiana</i> Card. & Broth - Dixon (1960: 15)	T
<i>D. hookeri</i> (C. M.) Card. (Syn. <i>Anisothecium hookeri</i>) - Dixon (1960: 15); Bartram (1959: 209)	T
<i>D. vaginata</i> (Hook.) Card. (Syn. <i>Anisothecium vaginatum</i>) - Dixon (1960: 15)	T
* <i>Dicranodontium insularum</i> Bartr. sp. nov. - Bartram (1959: 209)	G
* <i>D. tristaniense</i> Dixon & Thér. - Dixon (1960: 21); Bartram (1959: 209)	T
* <i>Dicranoloma atlanticum</i> Bartr. Sp. nov. - Bartram (1959: 209); Wace & Dickson (1965: 343)	
<i>D. hariotii</i> (C. M.) Par. - Dixon (1960: 17); Bartram (1959: 209)	T,I,G
<i>D. imponens</i> (Mont.) Broth. - Dixon (1960: 17); Bartram (1959: 209)	T,I,G
* <i>D. perdecurrens</i> Dixon - Dixon (1960: 17); Bartram (1959: 209)	T
* <i>Dicranoweisia falcifolia</i> Dixon - Dixon (1960: 16)	T
<i>Didymodon austroalpigena</i> (C. M.) Broth. - Dixon (1960: 23)	T
<i>Distichophyllum fasciculatum</i> Mitt. - Dixon (1960: 39)	T
<i>Ditrichum conicum</i> (Mont.) Par. - Dixon (1960: 12)	T
<i>D. flexifolium</i> (Hook.) Hampe. - Dixon (1960: 13)	T,I,N
<i>D. hyalinum</i> (Mitt.) Par. - Dixon (1960: 12)	T
<i>D. strictum</i> (H. f. & W.) Hampe - Dixon (1960: 12)	T,I
* <i>D. tenuinerve</i> Dixon - Dixon (1960: 12)	T
<i>Drepanocladus fluitans</i> (Hedw.) Warnst. - Dixon (1960: 42 as <i>Calliergon acuminatum</i> Dixon)	T
<i>Eustichia longirostris</i> (Brid.) C. M. - Dixon (1960: 34)	T,G
<i>Fissidens asplenioides</i> Hedw. - Dixon (1960: 11)	T,I
* <i>F. fluitans</i> Dixon - Dixon (1960: 10)	T
<i>F. leptochaete</i> Dus. - Dixon (1950: 12)	I

APPENDIX 7.2 – (continued)

TAXON NAME	DISTRIBUTION
* <i>Funaria euryloma</i> Dixon - Dixon (1960: 28)	T,I
<i>F. hygrometrica</i> Hedw. - Wace & Dickson (1965: 344)	T
<i>Grimmia kidderi</i> James - Dixon (1960: 23 as <i>Grimmia kerguelensis</i>)	T,G
* <i>G. stenobasis</i> Dixon - Dixon (1960: 23)	T
<i>Gymnostomum calcareum</i> Nees & Hornsch. - Wace & Dickson (1965: 343)	T
<i>Henediella kunzeana</i> (Müll. Hal.) Zander - Dixon (1960: 23 as <i>Tortula kunzeana</i>)	T
? <i>Hygroamblystegium fuegianum</i> (Besch.) Reimers, forma. - Dixon (1960: 41)	I
<i>Hypnum cupressiforme</i> Hedw. - Dixon (1960: 46); Bartram (1959: 210)	T,I,G
<i>H. cupressiforme</i> var. <i>subjulaceum</i> Mol. - Dixon (1960: 46); Bartram (1959: 210)	T,G
<i>H. chrysogaster</i> Müll. Hal. - Dixon (1960: 46 as <i>Hypnum elatum</i> Dixon)	T,I,N,G
* <i>Isopterygium ambiguum</i> Card. - Dixon (1960: 45)	T,N,G
<i>I. brownii</i> Card. - Wace & Dickson (1965: 345)	G
* <i>I. tristaniense</i> Dixon - Dixon (1960: 45)	T,N
<i>Leptodontium interruptum</i> (Mitt.) Broth. - Dixon (1960: 23)	T
<i>Leptotheca gaudichaudii</i> (Spreng.) Schwaegr. - Wace & Dickson (1965: 345)	G
? * <i>Lepydoron alaris</i> Dixon - Dixon (1960: 38)	T,G
<i>Macromitrium</i> sp. Brid. - Dixon (1960: 28)	
* <i>M. acutirameum</i> Mitt. - Dixon (1960: 6)	T
* <i>M. antarcticum</i> C. H. Wright - Dixon (1960: 28)	T,I,N,G
<i>M. fimbriatum</i> Schwaegr. - Dixon (1960: 28)	T
<i>Meiothecium urceolatum</i> (Schwaegr.) Broth. - Wace & Dickson (1965: 345)	T
<i>Neohodgsonia mirabilis</i> H. Persson - Bartram (1959: 210)	G
* <i>Oligotrichum tristaniense</i> Dixon - Dixon (1960: 47)	T
<i>Oncophorus fuegianus</i> Card. - Christopherson (1934: 9)	G
<i>Orthostichopsis subimbricata</i> (Hampe) Broth. - Wace & Dickson (1965: 345)	T
<i>Orthotheciella varia</i> (Hedw.) Ochyra - Dixon (1960: 40 as <i>Amblystegium excurrens</i> Broth. & Card.)	T
? <i>Pleuropus bonplandi</i> (Hook.) Broth. - Dixon (1960: 43)	T,I
* <i>Philonotis capillata</i> Mitt. - Dixon (1960: 36); Bartram (1959: 210)	T,G
<i>P. scabrifolia</i> (H. f. & W.) Mitt. - Dixon (1960: 36)	T
<i>P. tenuis</i> (Tayl.) Jaeg. - Dixon (1960: 36)	T,I,G
<i>P. vagans</i> (H. & W.) Mitt. - Christophersen (1934: 10); Dixon (1960: 36)	T,G
<i>Phyllogonium fulgens</i> (Sw.) Brid. - Wace & Dickson (1965: 345)	G
<i>P. viscosum</i> (Beauv.) Mont. - Bartram (1950: 210)	T,G
* <i>Physcomitrium aubertii</i> Besch. - Dixon (1960: 2)	T,I
<i>Pohlia elongata</i> Hedw. - Dixon (1960: 29)	T
* <i>Pohlia excurrens</i> (Dixon) E.B. Bartram - Christophersen (1934: 9 as <i>Webera excurrens</i> Dixon); Dixon (1960: 30)	T,I,G
<i>P. nutans</i> (Hedw.) Lindb. - Dixon (1960: 29)	T,G
<i>P. wahlenbergii</i> (Web. & Mohr) Andrews - Christophersen (1934: 10 as <i>Mniobryum albicans</i> (Wahlenb.) Limpr.); Dixon (1960: 30 as <i>Mniobryum wahlenbergii</i>)	T,G
<i>Polytrichadelphus magellanicus</i> (Hedw.) Mitt. - Dixon (1960: 49); Bartram (1959: 210)	T,I,G
? <i>Polytrichum gracile</i> Sm. - Wace & Dickson (1965: 345)	G
<i>P. juniperinum</i> Hedw. - Dixon (1960: 49)	T,I,N,G
<i>P. piliferum</i> - Ryan et al. (2007: 57)	
* <i>Porotrichum atlanticum</i> Dixon - Dixon (1960: 7)	T

APPENDIX 7.2 – (continued)

TAXON NAME	DISTRIBUTION
? <i>Pseudoscleropodium purum</i> (Limpr.) Fleisch. - Dickson (1967)	T
<i>Psilopilum antarcticum</i> (C. Muell) Par. - Wace & Dickson (1965: 345)	T
* <i>P. laxifolium</i> Dixon - Dixon (1960: 48)	T,I
* <i>P. tristaniense</i> Dixon - Dixon (1960: 48)	T
<i>Ptychomnion densifolium</i> (Brid.) Jaeg. - Dixon (1960: 38); Bartram (1959: 210)	T,I,G
<i>Pyrrhobryum spiniforme</i> (Hedw.) Mitt. - Dixon (1960: 34 as <i>Rhizogonium spiniforme</i>)	T,N
<i>Racomitrium</i> Brid. - Dixon (1960: 24 as <i>Rhacomitrium</i>)	
<i>R. crispulum</i> (H. f. & W.) H. f. & W. - Dixon (1960: 24; 25 as <i>R. heterostichoides</i> Card.)	T,I,G
* <i>R. decurrens</i> Dixon - Dixon (1960: 26)	T
* <i>R. gracillimum</i> Dixon - Dixon (1960: 26)	T
<i>R. laevigatum</i> A. Jae. - Dixon (1960: 26 as <i>R. breuteloides</i> Dixon); Wace & Dickson (1965: 344 as <i>Racomitrium loriforme</i> Dus.)	T,G
<i>R. lamprocarpum</i> (Müll. Hal.) Jaeg. - Dixon (1960: 25 as <i>R. subnigratum</i>); Ochyra (1999: 515)	T,G
<i>R. lanuginosum</i> (Hedw.) Brid. - Dixon (1960: 27); Bartram (1959: 209); Ryan et al. (2007: 57)	T,I,G
<i>R. nigratum</i> (C. M.) Jaeg. - Dixon (1960: 25)	T
? <i>R. symphyodontum</i> (C. Muell) Jaeg. - Wace & Dickson (1965: 344)	G
<i>Rhizogonium spiniforme</i> (Hedw.) Brunch. - Bartram (1959: 210)	T,N,G
* <i>Rhynchostegium irriguum</i> Dixon - Dixon (1960: 44)	T
* <i>R. isopterygioides</i> Card. - Dixon (1960: 44); Bartram (1959: 210)	T,I,N,G
? * <i>Rigodium crassicosatum</i> (Dix.) Bartr. - Dixon (1960: 43); Wace & Dickson (1965: 345)	T
<i>Sanionia uncinata</i> (Hedw.) Loeske - Dixon (1960: 41 as <i>Drepanocladus uncinatus</i> (Hedw.) Warnst.)	T
* <i>Schlotheimia atlantica</i> Dixon - Dixon (1960: 28)	T
<i>Sematophyllum crassiusculum</i> (Brid.) Broth. - Dixon (1960: 44)	T,I,N
<i>Sphagnum fimbriatum</i> Wils. - Bartram (1959: 208); Christophersen (1934: 10)	G
<i>S. magellanicum</i> Brid. - Bartram (1959: 208); Wace & Dickson (1965: 342)	G
<i>S.recurvum</i> Beauv. - Dixon (1960: 8); Bartram (1959: 208)	T,G,I
<i>S. violascens</i> Müll. Hal. - as <i>Sphagnum scotiae</i> Card. - Bartram (1959: 208), Christophersen (1934: 10)	G
<i>Syrrhopodon gaudichaudii</i> Mont. - Dixon (1960: 22 as <i>S. atlanticus</i> Dixon)	T,N,G
<i>Thuidium alvarezianum</i> Card. - Wace & Dickson (1965: 345)	G
<i>T.furfurosum</i> (H. f. & W.) Reich. - as <i>Thuidium curvatum</i> Mitt. - Dixon (1960: 40) and Bartram (1959: 209)	T,I,N,G
<i>Tortula kunzeana</i> (C. M.) Mitt. - Dixon (1960: 23)	T
<i>T. muralis</i> - Ryan et al. (2007: 57)	
* <i>Trematodon intermixtus</i> Card. - Dixon (1960: 15)	T,I
<i>Trichostomum</i> sp. - Dixon (1960: 22)	T
<i>T. aequatoriale</i> Spr. (Syn. <i>T. quitense</i> Hampe) - Dixon (1960: 22)	T
? <i>Weisia</i> sp. - Dixon (1960: 22)	T
* <i>Zygodon insularum</i> Dixon - Dixon (1960: 27)	T

