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SCIENTIA INSULARUM

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Revista

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Scientia Insularum wants to be a fast-publishing electronic journal with a short review and publication process of papers. It is also planned to compile specific volumes that would be published in paper format.

Scientia Insularum / Islands Science

Revista de Ciencias Naturales que tiene por contenido el *estudio de los organismos, los procesos ecológicos y geológicos en islas y el impacto de las actividades humanas sobre ellos*, tanto en el ambiente terrestre como en el marino. Con este objetivo tienen cabida trabajos de investigación en el ámbito de la Biología: *taxonomía, ecología, biogeografía, evolución y conservación*, así como aquellos más ligados a las Ciencias de la Tierra: *vulcanología, geomorfología, climatología y oceanografía*. Con este enfoque, *Scientia Insularum* pretende ser una revista que aborde de manera integral el estudio de la naturaleza de las islas y así ahondar en el conocimiento de su biodiversidad y de los procesos geológicos y ecológicos que la determinan.

Natural Science journal that has as content *the study of organisms, ecological and geological process in Islands and the impact of human activities on them*, in both terrestrial and marine environments. With this objective, we welcome biological studies on *taxonomy, ecology, biogeography, evolution and conservation*; as well as those related with Earth Science on *volcanology, geomorphology, climatology and oceanography*. With this scope, the *Journal of Islands Science* pretend to be a journal that integrates the study of islands nature to promote wider knowledge of its biodiversity and the geological and ecological process that determine it.

Esta revista surge por la necesidad de tener un espacio común para la difusión y reflexión sobre los procesos singulares que ocurren en las islas y que las hace auténticos laboratorios naturales. Estas materias son, además, objeto de enseñanza y estudio en dos másteres oficiales de la Universidad de La Laguna: «Biodiversidad Terrestre y Conservación en Islas» y «Biología Marina: Biodiversidad y Conservación». Por lo que este compendio anual de trabajos puede servir de apoyo didáctico a profesores y alumnos de dichos másteres, y para ayudar a aquellos estudiantes que tengan una vocación más científica y quieran dar sus primeros pasos en la publicación de sus trabajos.

This journal arises to have a common space for the dissemination and reflection of the singular processes that occur in islands, and that makes them genuine natural laboratories. These knowledge topics are also studied in our official master programs of the Universidad de La Laguna: "Terrestrial Biodiversity and Conservation on Islands" and "Marine Biology: Biodiversity and Conservation". In this sense, these annual issues will act as a teaching support for professors and students of these masters, and to help those students with scientific vocation looking for their first steps on the publication of their studies.

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SUMARIO / CONTENTS

Miguel Menezes de Sequeira*
Lea de Nascimento**
José María Fernández-Palacios**

INTRODUCTION

During the last ten years, since 2010, FloraMac meetings have taken place, providing an important opportunity for the interchange of ideas and advancing our knowledge of the Macaronesian flora. Every two years, researchers from different countries, specialists in areas as distinct as history, geology, floristics, ecology and biogeography, converge to further investigate the flora of Macaronesia, one of the most important insular regions of the world.

As well as a showcase for the latest research, FloraMac meetings constitute an opportunity for young scientists, interested in the knowledge and conservation of the unique natural heritage of the region, to take their first steps in communicating their science in the company of renowned scientists.

The proceedings of the most recent FloraMac meeting which took place in Funchal, Madeira, in 2018, are published in this issue of *Scientia Insularum,* a young open access journal very much in line with the meeting's spirit, in which established scientists publish beside novel authors.

INTRODUCCIÓN

Durante los últimos diez años, desde 2010, han tenido lugar los congresos FloraMac, permitiendo una oportunidad importante para el intercambio de ideas y para el avance del conocimiento de la flora macaronésica. Cada dos años investigadores de diferentes países, especialistas en campos tan diversos como historia, geología, florística, ecología y biogeografía, convergen para profundizar en el estudio de la flora de Macaronesia, una de las regiones insulares mas importantes del mundo.

Además de un escaparate para las investigaciones más actuales, los congresos de FloraMac constituyen una oportunidad para jóvenes científicos, interesados en el conocimiento y conservación del patrimonio natural único de la esta región, para dar sus primeros pasos en comunicar sus investigaciones en compañía de científicos de renombre.

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Las actas del congreso más reciente de FloraMac, que tuvo lugar en Funchal, Madeira, en 2018, son publicados en este volumen de *Scientia Insularum*, una joven revista de acceso abierto, muy en la línea del espíritu del congreso, en el que investigadores de prestigio publican junto a autores noveles.

GREEN GARDENS AZORES PROJECT: A BRIEF CHARACTERIZATION OF THE VASCULAR FLORA IN THE AZORES' HISTORICAL GARDENS

Maria João Pereira*, Raimundo Quintal**,
Carina Costa*** & Isabel Albergaria****

Abstract

The Green Gardens Azores Project is part of the action plan for tourism development in Portugal (2014-2020) aiming to integrate the Azorean Gardens in the circuit of international 'Garden Tourism'. With that purpose we built a checklist of the vascular plants cultivated in 8 Azorean Historical Gardens. The analysis of this checklist reveals a richness of 1884 specific and infra-specific *taxa*, hybrids and cultivars. This richness is represented by 168 families, 514 genera, 991 species, 288 hybrids and 958 cultivars. *Camellia* hybrids correspond to 60% of all the hybrids and *Camellia* cultivars represent 71% of all the cultivars. *Zamiaceae* is the family best represented with 73 species while the best represented genera are *Encephalartos* with 48 species and *Camellia* with 45 species. The presence of 5 species extinct in the wild and 96 threatened species in the Azorean Gardens stresses the role of the Gardens in the Conservation of World Flora.

Keywords: Azores, Garden flora, Garden tourism.

EL PROYECTO «JARDINES VERDES DE AZORES»: BREVE CARACTERIZACIÓN DE LA FLORA VASCULAR DE LOS JARDINES HISTÓRICOS DE AZORES

Resumen

El proyecto «jardines verdes de Azores» es parte de un plan de acción para el desarrollo turístico de Portugal (2014-2020) pretendiendo integrar estos jardines en el circuito internacional de jardines turísticos. Con este propósito hicimos la redacción de un listado de plantas vasculares cultivadas en ocho jardines históricos de Azores. El análisis del listado señaló una riqueza de 1884 categorías específicas, infraespecíficas, híbridos y cultivares. Esta riqueza está representada por 168 familias, 514 géneros, 991 especies, 288 híbridos y 958 cultivares. El género *Camellia* contribuye con un 60% de todos los híbridos y un 71% de todos los cultivares. *Zamiaceae* es la familia mejor representada con 73 especies, mientras que los géneros mejor representados son *Encephalartos* con 48 y *Camellia* con 45 especies. La presencia de cinco especies extintas en la naturaleza y 96 especies amenazadas en los jardines de Azores subrayan el papel que estos juegan en la conservación de la flora mundial.

Palabras clave: Azores, flora de jardín, turismo de jardines.

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1. INTRODUCTION

For their historical, botanical, and landscape value, the gardens of the Azores are an important heritage that can answer to the global demand of 'Garden Tourism' (Benfield 2013; Čakovská 2018). If we want to understand the economic impact of garden tourism, we can take as an example the fact that in 2014, 20 million paid entries were registered in the National Trust's British Gardens (National Trust 2014). Until now tourism at the Azores has been grounded on 'Nature Tourism' and 'Adventure Tourism' (Fraga 2014; Governo dos Açores 2016; Guerreiro 2017; Ponte et al. 2018). Nevertheless, there are evident advantages in developing the segment of garden tourism at the Azores, not only because garden tourism is suitable for a greater number of people than adventure or nature tourism, but also because these segments of tourism represent complementary niche markets that are not associated with mass tourism. In the Azores the growing world demand regarding the uses of gardens, has corresponded: to an increasing number of visits and visitors (SDEA 2018; SREA 2019); to the acknowledgment of Terra Nostra Garden international distinctions (Cox et al. 2014; ICS 2019); and to the organization of thematic guided tours (Haslemere Travel 2013), International Meetings of Ancient Camellias at Furnas in São Miguel Island (ICS 2007), and several scientific, educational and cultural events in the gardens.

The present study resulted from the Azores Green Gardens Project implementation (Green Gardens Azores 2019). This project is part of the Action Plan for Tourism Development in Portugal and aims to integrate the Azorean Gardens in the Circuit of International Garden Tourism. The project, co-financed by the European Regional Development Fund through the Operational Program 'Azores2020', is promoted by the Azores Tourism Observatory, with the Azores University and Gaspar Frutuoso Institution as co-promotors, and involves several other Azorean private and public institutions. Broadly this project is developed in two steps: a) gardens selection and characterization and b) design of communication and dissemination strategies and their implementation and evaluation. To this project several sites were selected, including Faial Botanic Garden, Pinhal da Paz Park, and two vineyards at Pico and Terceira Islands; but this study aimed the characterization of the vascular flora present only on the nineteen century historical gardens: one from Terceira Island (Duque da Terceira Garden) and 7 from São Miguel Island (António Borges Garden, Sant'Ana Garden, José do Canto Garden, Azores University Garden, José do Canto Woodland Garden, Beatriz do Canto Park and Terra Nostra Garden) (figure 1).

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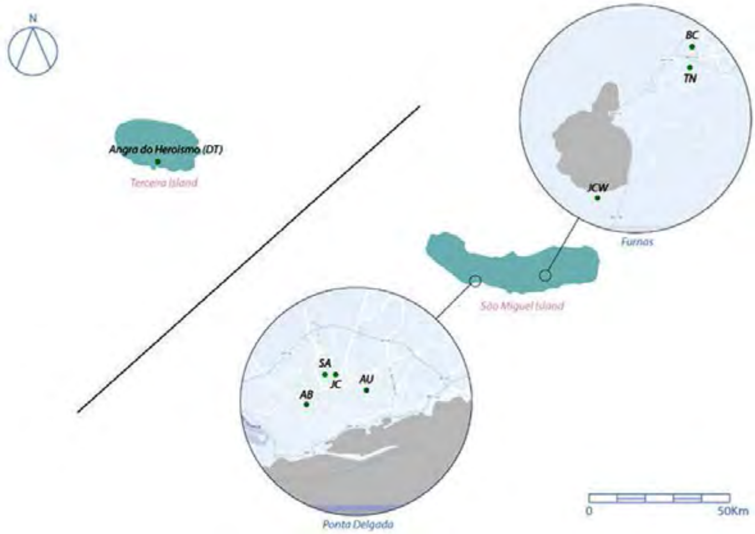

Figure 1. Locations of the gardens at Terceira and São Miguel islands: DT- Duque da Terceira Garden; AB - António Borges garden; SA - Sant'Ana garden; JC - José do Canto garden; AU Azores University Garden; JCW - José do Canto Woodland Garden; BC - Beatriz do Canto park; TN - Terra Nostra (courtesy of Ricardo Cruz architect).

2. MATERIAL AND METHODS

2.1. Study sites

The criteria to select the Azorean gardens and parks were the following: to be visitable, and accessible, possess maintenance services and facilities, and have historical, botanical, and landscape interest. Regarding the selected gardens, the first one to be established as a romantic garden, was the summer house called "Yankee Hall" in Furnas which became the genesis of the present Terra Nostra Garden (Carvalho 2017). All the other gardens are formed practically in the second half of the nineteen century (Albergaria 2005). José do Canto Woodland Garden is the one situated at the higher altitude, between 283 and 330 m, while the António Borges Garden is the garden located at the lowest altitude (20 m). José do Canto Woodland Garden has also the largest area with 120 ha, while the Azores University Garden has the smallest area only with 1.5 ha (table 1).

Regarding the gardens typology, the Terra Nostra Garden in its origin it's a romantic garden, but with time several elements were transformed or added (Albergaria 2000). The original cold water lake with canoes was replaced with a natural thermal water pool. Other elements were added as the memorial lane, and later, the *Victoria cruziana* A.D. Orb. tank, some animals covered with creeping plants and new formal flower beds (Albergaria 2000; Carvalho 2017). The Garden of Sant'Ana brings together the romantic elements such as the lake with the anchorage point and formal elements like the 'parterre' in front of the palace, assuming itself as a botanical park with a collection of exotic species (Albergaria 2000). José do Canto Garden is also a botanical park in the sense that it maintains and increases their plant collection, but we can also find the original romantic and formal elements as the small pond and the rose garden, respectively (Albergaria 2000). José do Canto Woodland Garden corresponds to a vast area of spontaneous native and exotic naturalized or invasive species, coexisting with the exotic species initially planted by José do Canto (Albergaria 2000). Beatriz do Canto Park, António Borges Garden, and Azores University Garden are in their essence romantic gardens with more or less sophisticated water elements from the water stream with small cascades and a water wheel at Beatriz do Canto Park to small artificial lake at Azores University Garden (Albergaria 2000). The artificial volcanic rock grottoes are also romantic features present *symbolically* at *Azores* University Garden *but much more* elaborated at António Borges Garden (Albergaria 2000). Finally, the typology of Duque da Terceira Garden, is that one of a public garden with an access to the higher part of the town and to the monument 'Alto da Memória' (Albergaria 2005).

TABLE 1. LOCATION AND APPROXIMATE DATES OF FORMATION, AREAS AND ALTITUDES OF THE SELECTED HISTORICAL AZOREAN PARKS AND GARDENS (ALBERGARIA, 2005)

Name	Location	Year	Approximate areas (ha)	Approximate altitudes (m)
Terra Nostra Garden	Furnas	1785	12,5	200
José do Canto Garden	Ponta Delgada	1845	5,8	40 - 70
Sant'Ana Garden	Ponta Delgada	1850	7,5	40 - 80
José do Canto Woodland Garden	Furnas	1852	120	280 -330
António Borges Garden	Ponta Delgada	1858	3	20
Beatriz do Canto Park	Furnas	1860	3,7	200
Duque da Terceira Garden	Angra do Heroísmo	1882	1,7	20 - 80
Azores University Garden	Ponta Delgada	1897	1,5	30 - 40

2.2. Plant list database and plant identifications

An excel worksheet was used to create the plant list database for the Azorean historical gardens. Plant names were gathered from published and non-published plant lists of the selected gardens and parks (table 2). Plant names were checked for synonyms using 'The Plant List' (2013) data base; we adopted the scientific names with the status 'Accepted' (e.g. *Araucaria heterophylla* (Salisb.) Franco). For the 141 *taxa* names with 'Unresolved name' status (e.g. *Viburnum treleasei* Gand.), we analyse the respective recent published scientific taxonomic works (e.g. Moura et al. 2015). Also, from 2016 to 2018 several visits were made to the listed gardens and parks; during the visits digital images of selected specimens were taken and when needed parts of the plants were collected for posterior identification using regional floras, field guides, scientific papers and electronic databases. Table 3 lists the information gathered in the plant list data base for the Azorean historical gardens.

TABLE 2. DATA SOURCES FOR PLANT NAMES (HD - HISTORICAL DOCUMENT; ITD - INTERNAL TECHNICAL DOCUMENT; B - BOOK)

Name	Available lists	Type of document
Terra Nostra Garden	Costa 2018 - ITD	ITD
José do Canto Garden	Canto 1856	HD
	Quintal and Braga 2018	B
Sant'Ana Garden	Canto 1856	HD
	Pacheco 2016	ITD
José do Canto Woodland Garden	Quintal 2015, 2018	ITD
António Borges Garden	Topiaris 2008	ITD
Beatriz do Canto Park	Quintal 2018	ITD
Duque da Terceira Garden	CMAH 2017	ITD
Azores University Garden	Pereira et al. 2010	B

TABLE 3. INFORMATION AT AZORES' HISTORICAL GARDENS PLANT DATABASE

Floristic composition	Species name
Name status	Accepted / Unresolved
Species Conservation Status	IUCN categories
Species status to the Azores	Exotic / Native
Group	*Pteridophyta* / *Pinophyta* / Dicotyledon / Monocotyledon
Taxon categories	Family / Genus / Species / Subspecies / Variety / Form / Hybrid
Cultivars	Species cultivars / Species variety cultivars/ Hybrid cultivars
Origin	Horticultural / Natural [Native of (geographic region)]
Habit growth form	Herbs / Shrubs / Trees / Palms / Climbers / Ferns

Data analysis. To the 8 historical gardens the plant list resulted in a database with 1884 plant entries. Some species are represented only by a particular subspecies; variety or cultivar. From this database 'richness' (the number of different plants present in the studied sites) was calculated independently for the *Pteridophyta, Pinophyta*, dicotyledons and monocotyledons, and for the families, genera, species, subspecies, varieties, forms, cultivars and hybrids. Families representativeness at the Azores' historical gardens, regarding the total of extant families on the world plant list data base (The Plant List 2013) was calculated. We also calculated the proportions: of different hybrids and cultivars, of different origins, and of different habit growth forms.

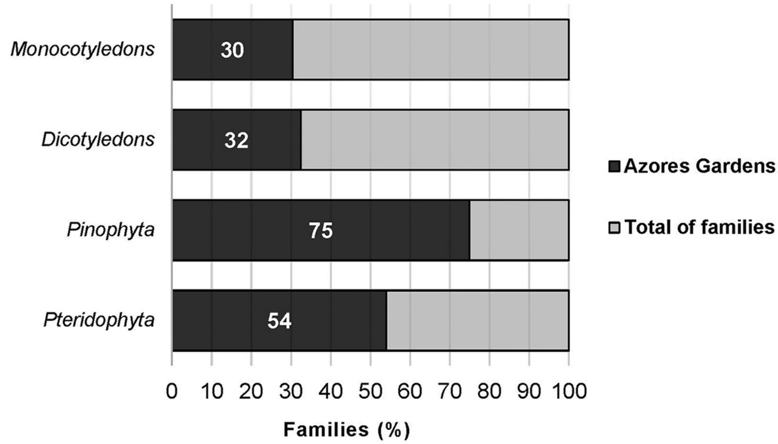

Figure 2. Representativeness of *Pteridophyta*, *Pinophyta*, dicotyledons, and monocotyledons families in the Azores' historical gardens (total number of families estimated by The Plant List, 2013).

3. RESULTS

The data base analysis reveals 1884 different plant entries that correspond to 168 families, 514 genera, 991 species, 958 cultivars, and 288 hybrids (table 4). Although Pinophyta are the group with the fewest families, in fact they are the best represented group since Azorean gardens own 75% of the *total Pinophyta* families registered in The Plant List (2013) database (figure 2). *Arecaceae* is the family represented by the large number of genera with 19 genera; while *Zamiaceae* is the family represented by the large number of species with 73 species; also the best represented genera are *Encephalartos* (with 48 species) and *Camellia* (with 45 species) (table 5). *Camellia* hybrids correspond to 60% of all the hybrids and *Camellia* cultivars represent 71% of all the cultivars (table 6).

TABLE 4. RICHNESS VALUES CALCULATED INDEPENDENTLY FOR EACH PLANT GROUP FOR 8 HISTORICAL GARDENS AT AZORES ISLANDS (DUQUE DA TERCEIRA, ANTÓNIO BORGES, SANT'ANA, JOSÉ DO CANTO, AZORES UNIVERSITY, JOSÉ DO CANTO WOODLAND GARDEN, BEATRIZ DO CANTO PARK, AND TERRA NOSTRA GARDEN)

Group	Totals	*Pteridophyta*	*Pinophyta*	Dicotyledons	Monocotyledons
Frequency	**1884**	205	138	1261	280
Families	168	27	9	108	24
Genera	514	61	34	300	119
Species	**991**	166	127	492	206
Subspecies	6	1	0	4	1
Varieties	31	5	2	15	9

Forms	3	1	1	1	0
Cultivars	**958**	60	11	802	85
Hybrids	**288**	2	1	232	53

TABLE 5. BEST REPRESENTED FAMILIES AND GENERA AT THE AZOREAN HISTORICAL GARDENS

Family	Number of Genera	Family	Number of Species	Genus	Number of Species
Arecaceae	19	*Zamiaceae*	73	*Encephalartos*	48
Myrtaceae	18	*Theaceae*	48	*Camellia*	45
Asparagaceae	17	*Bromeliaceae*	46	*Tillandsia*	22
Asteraceae	17	*Myrtaceae*	43	*Quercus*	16
Fabaceae	17	*Poaceae*	32	*Blechnum*	15
Poaceae	17	*Pteridaceae*	32	*Dryopteris*	13
Bromeliaceae	13	*Asparagaceae*	31	*Pteris*	13
Amaryllidaceae	12	*Arecaceae*	28	*Cycas*	11
Rosaceae	11	*Dryopteridaceae*	26	*Polystichum*	11
Cupressaceae	10	*Blechnaceae*	24	*Acer*	10
Ericaceae	10	*Ericaceae*	21	*Ficus*	10
Malvaceae	9	*Fagaceae*	21	*Rhododendron*	10
Pteridaceae	8	*Fabaceae*	20	*Adiantum*	9
Solanaceae	8	*Asteraceae*	18	*Cyathea*	9
Zamiaceae	8	*Cupressaceae*	18	*Eucalyptus*	8
Araceae	7	*Proteaceae*	16	*Asplenium*	7
Iridaceae	7	*Sapindaceae*	15	*Vriesea*	7
Polypodiaceae	7	*Rosaceae*	14	*Aechmea*	6
Acanthaceae	6	*Moraceae*	14	*Araucaria*	6
Apocynaceae	6	*Malvaceae*	13	*Bambusa*	6
Lauraceae	6	*Solanaceae*	13	*Banksia*	6
Oleaceae	6	*Amaryllidaceae*	12	*Ceratozamia*	6
Pinaceae	6	*Polypodiaceae*	12	*Macrozamia*	6
Proteaceae	6	*Oleaceae*	12	*Magnolia*	6
Xanthorrhoeaceae	6	*Pinaceae*	11	*Salvia*	6
Bignoniaceae	5	*Lamiaceae*	11		
Blechnaceae	5	*Cycadaceae*	11		
Lamiaceae	5	*Acanthaceae*	10		
Moraceae	5	*Cyatheaceae*	10		
Sapindaceae	5				
Remaining families	≤ 4	Remaining families	≤ 9	Remaining genera	≤ 5

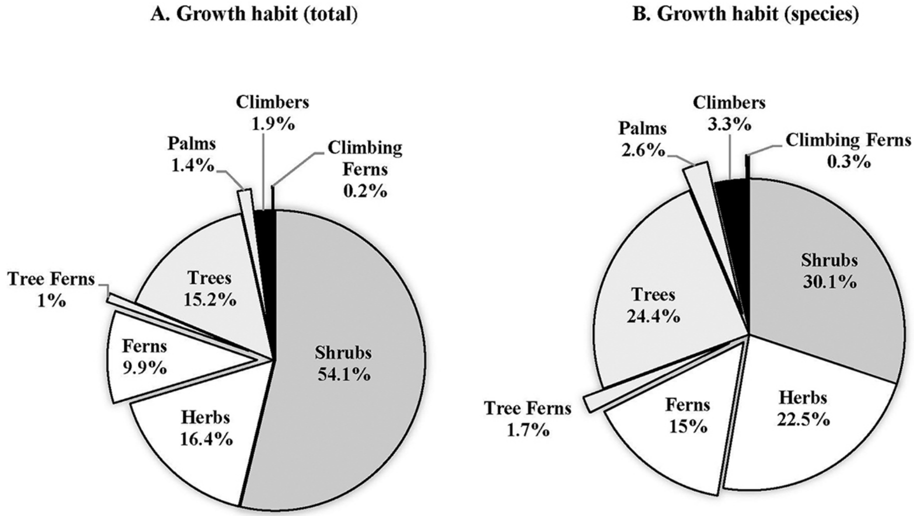

Figure 3. Growth habit distribution for the total of the plant database entries (A) and for the species (B).

TABLE 6. DISTRIBUTION OF HYBRIDS AND CULTIVARS AT THE AZOREAN HISTORICAL GARDENS BY GENERA. (OTHERS = LESS THAN 5 HYBRIDS OR CULTIVARS PER GENUS)

Genera	Hybrids (%)	Cultivars (%)
Camellia	60	71
Rhododendron	7	2
Gusmania	5	2
Acer		2
Vriesea	4	1
Canna	2	
Magnolia	2	
Others	20	22

Nearly half (49,2%) of the data base entries correspond to plants with horticultural origin. Also, nearly half (54%) of all the entries of the database represent shrubs (figure 3A) but at species level the shrubby growth habit decreases to 30.1% of the database entries (figure 3B).

Regarding the nativity of plant species Asia is the geographic region best represented in the gardens with 354 species (29%) of which 254 species are exclusively from Asia, followed by the plants native from the Americas (26%) (figure 4).

Also, 96 of the species found at Azorean Gardens are under a IUCN (2012) threatened species category. Five species are extinct in the wild (e.g. *Encephalartos*

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 11-26

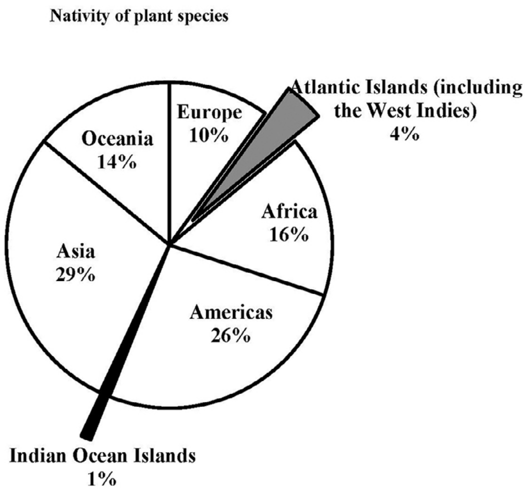

Figure 4. Nativity of plant species found at the Azorean Gardens.

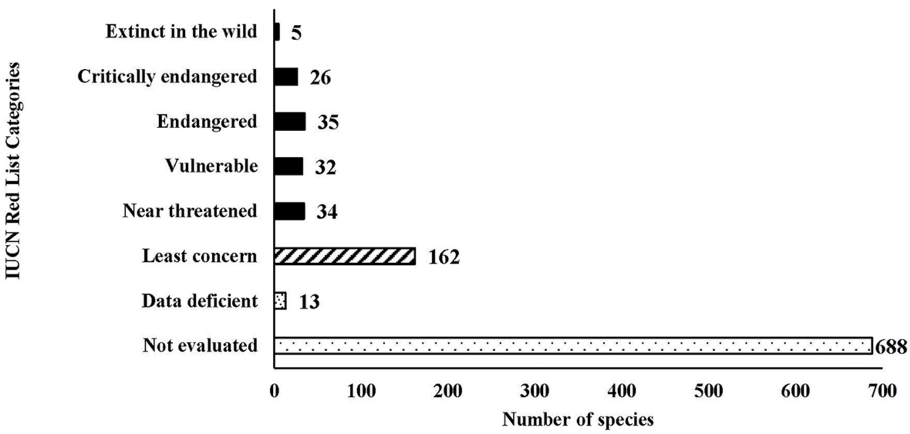

Figure 5. Conservation status: IUCN categories for the species found at the Azorean Gardens.

nubimontanus P.J.H. Hurter and *Encephalartos woodii* Sander) and 26 species are critically endangered (e.g. *Aechmea apocalyptica* Reitz, *Camellia impressinervis* H.T. Chang & S.Y. Liang, *Wollemia nobilis* W.G. Jones, K.D. Hill & J.M. Allen, and *Zamia vazquezii* D.W. Stev., Sabato & De Luca) (figure 5).

In a different analysis, 88 species found at Azorean Gardens are naturalized in the Azorean landscape including the worst invasive species at Azores as *Pittosporum undulatum* Vent. and *Hedychium gardnerianum* Sheppard ex Ker Gawl.

Finally, the number of listed species is very different between the surveyed gardens: Terra Nostra Garden possesses the highest number of species, genera and families (respectively 70%, 70% and 80% of the total database entries) (table 7). Also, Terra Nostra Garden possesses the largest collection of *Camellia* hybrids and cultivars (table 7).

TABLE 7. COMPARATIVE RICHNESS IN THE AZOREAN HISTORICAL GARDENS					
Categories	Species	Genera	Families	Hybrids	Cultivars
Number of total listed categories	991	514	168	288	958
Terra Nostra Garden	691	360	135	266	859
José do Canto Garden	283	227	109	7	12
José do Canto Woodland Garden	195	144	78	7	16
Sant'Ana Garden	189	140	61	20	34
Duque da Terceira Garden	134	122	68	6	6
Azores University Garden	100	88	53	4	1
António Borges Garden	62	53	32	3	1
Beatriz do Canto Park	53	49	34	3	3

4. DISCUSSION

The analysis of the extensive list elaborated by José do Canto in 1856 reveals that a substantial part of the imported plants has been lost. Although this study verified the specimens' existence in the Azorean historical gardens according to the extant lists of plant names, several specimens found on the gardens still lack identification and many ornamental herbaceous plants are not listed. It is also necessary validate the specimens' identification with vouchers properly preserved at registered Herbariums. Therefore, it is expected that the total richness of Azorean gardens will increase with further studies and some specimens may have their identification rectified.

Nowadays the Azorean gardens under public administration tend to preserve the existent specimens while private gardens linked to hotels (Terra Nostra and José do Canto gardens) are increasing their plant collections due to the development of touristic activity.

In relation to the *Azores, the island* of Madeira has a greater number of historical farms and gardens sooner linked to *tourism*, which helps to explain, the maintenance of high specific diversity in these *gardens* (table 8). As in Portuguese mainland (Silva and Carvalho 2015), the preservation of old specimens and the high numbers of cultivated *taxa* and cultivars in the private insular historical gardens are linked to the resources obtained from the economic activity of tourism (e.g. Parque terra Nostra possesses 1532 plant entries considering all the *taxa* and cultivars).

Considering the Azorean historical gardens, Terra Nostra Garden possesses the highest number for species specific richness (691), and is comparable in area and floristic richness to Quinta do Palheiro Ferreira at Madeira Island (table 8). Due to their mission the Portuguese Historical Botanical Gardens continuous to be the leaders in floristic richness: Madeira Botanical Garden with 3000 *taxa*, Botanical Garden of Lisbon University with 1086 *taxa,* and Botanical Garden of Ajuda with 1300 *taxa* (IFCN 2019; BGCI 2019).

TABLE 8. PLANT RICHNESS BETWEEN THE PORTUGUESE ARCHIPELAGOS OF AZORES AND MADEIRA. *DATA FROM QUINTAL (2007)

	Historical Gardens (17th-19th centuries)	Area (ha)	Families (n)	Genera (n)	Species (n)
Azores	Terra Nostra Garden	12,50	135	360	691
	José do Canto Garden	5,80	109	227	283
	José do Canto Woodland Garden	120,00	78	144	195
	Sant'Ana Garden	7,50	61	140	189
	Duque da Terceira Garden	1,70	68	122	134
	Azores University Garden	1,50	53	88	100
	António Borges Garden	3,00	32	53	62
	Beatriz do Canto Park	3,70	34	49	53
Madeira	Quinta do Palheiro Ferreiro	14,30	136	420	631
	Quinta Monte Palace	5,67	131	339	484
	Estalagem Jardins do Lago	1,37	113	336	433
	Quinta Palmeira	3,41	118	313	414
	Quinta Jardins do Imperador	3,85	96	223	284
	Quinta da Magnólia	2,47	95	221	263
	Quinta da Vigia	0,56	88	216	260
	Jardim do Hotel Quinta das Vistas	0,80	77	159	186
	Quinta da Bela Vista	1,06	87	171	185
	Pousada da Juventude Garden	0,21	73	132	156
	Hotel Pestana Casino Park Garden	2,32	74	142	155

Contrarily from the 179 worldwide botanic gardens analysed by Golding et al. (2010), we didn't find a correlation (Pearson correlation coefficient = 0,002) between the Portuguese insular historic gardens' areas and the number of plant species (table 8).

At the Azorean historical gardens, the good representativeness of *Pteridophyta* and *Pinophyta* families is mainly explained by the fern and *Cycadales* collections at Terra Nostra Garden. A brief analysis of families and genera representativeness highlight the importance of the 19 genera of palms (*Arecaceae*) collection on all the Azorean historical gardens, and the important collections of *Zamiaceae* (73 species) and *Camellia* (45 species) at Terra Nostra Garden.

Hybrids and cultivars of camellias dominate the lists of hybrids and cultivars present at the Azorean gardens. Once again the collection of camellias at Terra Nostra Garden has 680 plant entries in the total database, placing this garden in the world list of 'Gardens of Excellence' (ICS 2019).

The shrub habit of growth dominates both total entries in the database and plant species. If we considered all the woody plants (shrubs and trees) they represent 69.3% of the total listed plant names. Nevertheless, the extant lists do not consider many ornamental herbaceous plants.

In spite of the ornamental value of many native Azorean species (Amazon 2019; Future Forests 2019), the local flora is almost neglected at the Azorean historical gardens. The specimens represent probably non planted specimens left in the gardens (as the *Picconia azorica* (Tutin) Knobl. tree), or result of spontaneous establishment (e.g. the fern *Polypodium macaronesicum* A.E.Bobrov subsp. *azoricum* (Vasc.) F.J. Rumsey, Carine & Robba). For many years only Terra Nostra Garden had a collection of woody Azorean native species. Today, the native Azorean flora is valued in the tourism market and consequently native specimens receive identification tags and plantations of several endemic Azorean species were made in the last years at José do Canto and Terra Nostra private gardens.

The European flora is poorly represented at the Azores historical gardens and embodies only 10% of the total plant database entries, reflecting one of the European naval expeditions purposes of collecting plants across the Atlantic, Indian and Pacific oceans (Taillemite 2004; Rice 2010). Species native to Asia and/or Oceania represent 43%, of all the species present at the Azorean gardens. At 19th century plants from Asia and Oceania were the novelty since they resulted from the last great expeditions around the world at the end of 18th century; the *Araucaria heterophylla* tree is a good example, since this coastal species was first seen by Captain Cook from the sea in 1774 on his second voyage around the world (Hooker 1843).

Although the botanical gardens were, in a historical context, responsible for the introduction of many exotic species that later became invasive (Galera and Sudnik-Wócikowska 2010; Hulme 2015; Guo et al. 2019) today many botanical gardens including the historical ones have programs for rare species conservation (Chenabc and Sunabc 2018). In the current Azorean gardens' database only 4,7% of plant entries correspond to escaped naturalized plants while 5,2% of plant entries correspond to extinct in wild or under some IUCN (2012) threatened species category. Nevertheless, the percentage of escaped and naturalized plants will increase if we included in the database all the current exotic non-cultivated flora present at the gardens. The recent pressure to recover and improve these historical gardens with new species and cultivars, stresses the importance to perform a risk assessment analysis for any species that is intended to introduce at the gardens (Daehler and Carrino 2000; Groves et al. 2001; Conser et al. 2015). At the same time due to the rarity of many endemic Azorean plants species, the Azorean gardens should play a more important role in their conservation.

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6. AUTHORS CONTRIBUTION

I. Albergaria conceived the present study; R. Raimundo, M.J. Pereira and C. Costa analysed the extant plant lists, locate the plants at the gardens and verify the existing identifications. M.J. Pereira treated the data and took the lead in writing the manuscript but all the authors provided critical feedback.

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TWO HUNDRED AND FIFTY YEARS AGO: THE BANKSIAN BOTANICAL 'SUITE' ARRIVES IN MADEIRA ON HMS *ENDEAVOUR*

Jordan Goodman*

ABSTRACT

HMS *Endeavour*, the first British ship to circumnavigate the world on a scientific mission, had its first stop in Funchal on 12 August 1768 on the way to the Pacific. It was not a big ship and it sailed on its own. Not only was this a scientific voyage –initially making for Tahiti where Venus's track across the sky could be accurately measured– but it had a remarkable and unique entourage dedicated to observing and recording the natural world. Though the ship's commander, Lieutenant James Cook, had a good reason to call into the island's principal port, it could have been otherwise: sea conditions, unpredictable at the best of times, might have forced him to head for Tenerife instead. Had this happened, the botanical history of Madeira might have been quite different. Fortunately for Joseph Banks and Daniel Solander, the ship's botanists, the sea was kind and the two men, the latter Linnaeus's best student, were able to bring Hans Sloane's pioneering botanical observations, made more than seventy years earlier, into the modern age.

KEYWORDS: Banks, Botanical history, *HMS Endeavour,* Madeira, Solander.

HACE 250 AÑOS: BANKS LLEGA A MADEIRA EN EL *ENDEAVOUR*

RESUMEN

El *Endeavour*, el primer barco inglés en circunnavegar el Globo en misión científica, hizo su primera parada en Funchal el 12 de agosto de 1768, en su camino hacia el Pacífico. No era un barco grande y navegaba por sí mismo. Además de su principal misión –observar y medir el tránsito de Venus en Tahití–, debía observar y registrar la naturaleza de los lugares visitados. Pese a que el comandante de la nave, el teniente James Cook, tenía buenas razones para recalar en Funchal, las condiciones del mar, del todo impredecibles, le habrían podido forzar a recalar más al sur, en Tenerife. De haber ocurrido esto, la historia botánica de Madeira hubiera sido bien diferente. Afortunadamente para los dos botánicos de a bordo, Joseph Banks y Daniel Solander, este último el mejor discípulo de Linneo, el mar estaba en calma, lo que les posibilitó conocer Madeira, y de esta manera recuperar las pioneras observaciones botánicas realizadas unos setenta años antes de esta visita por Hans Sloane, para la modernidad.

PALABRAS CLAVE: Banks, *Endeavour*, Historia de la Botánica, Madeira, Solander.

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1. INTRODUCTION

My intention in this paper is to go behind the scenes of this very famous expedition, to explain how it was put together, how the ship, its commander and particularly its entourage of 'scientific gentlemen' came to sail together and to the island of Madeira, what they did here and what significance it held especially for the two botanists, Joseph Banks and Daniel Solander, and the principal artist, Sydney Parkinson.

My main argument is that were it not for two historical tipping points, the *Endeavour* would not have visited Madeira, history would have been different, and this paper would have had no reason to be written. But before discussing these tipping points, it is necessary to fill in the background to the reasons for the *Endeavour's* voyage in the first place.

There are many beginnings to the voyage but my story starts on 15 February 1768 for it was then that King George III received a 'Memorial for Improving Natural Knowledge' from London's Royal Society (Carter 1995; Cook 2004). The Society was appealing to the King for his financial support to send men and instruments to a convenient spot in the southern hemisphere somewhere in a rectangle bounded by a latitude 'not exceeding 30 degrees [south] and between the 140th and 180th degrees of longitude west', determined by Nevil Maskelyne, the Astronomer Royal, as the best place to observe the transit of Venus, predicted to be visible there on 3 June 1769 –the next event would not occur again until 1874 (the original memorial is in the Royal Society Archives, RS Misc. MSS V 39; Williams 1998). The Royal Society had been discussing how they would contribute to observing and measuring this rare but crucially important astronomical event, from which they hoped they could calculate the size of the solar system, since at least June 1766. On 19 November 1767, the Society's newly–constituted Committee for the Transit had agreed the general plan of sending observers to the south, and that the ship taking them to the Pacific would need to be rounding Cape Horn no later than January 1769 (Beaglehole 1955). Time was running out for adequate preparations to be made. 'The Royal Society', the memorial pleaded, 'was in no condition to defray this Expence (which they had estimated at £4000 –£400,000 in today's money– not including the cost of the ships), their Annual Income being scarcely sufficient to carry on the necessary business of the Society'. Time was of the essence. Several other European powers (France, Spain, Denmark and Russia were singled out) were already making their own preparations for the event and Britain, in the forefront of astronomical science, simply could not afford to be a bystander. The memorial was signed by James Douglas, Earl of Morton, the Society's president, and fourteen fellows including Benjamin Franklin and Nevil Maskelyne (Beaglehole 1955; Woolf 1959; Wulf 2012).

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By late February 1768, the King had given his consent to defray the costs of sending observers to the southern hemisphere and, at the same time, he ordered the Admiralty to provide a suitable ship to take them to their destination (Carter 1995; Beaglehole 1955; Knight 1933). By the end of March, the Admiralty had agreed which ship to purchase. It was called the *Earl of Pembroke*. It had been built in Whitby a little more than three years earlier and was currently lying unused in the Thames to the east of the present location of Tower Bridge. Just over a week later, on 5 April, the Admiralty informed the Navy Board, who were responsible for the day-to-day administration of the Royal Navy, that the ship, now renamed HMS *Endeavour*, and at the relatively small size of 32 metres long and 9 metres wide (the Titanic was almost ten times longer and a football pitch is three times longer), should be prepared and armed as necessary for 'conveying to the southward such persons as shall be thought proper for making observations on the passage of the planet Venus over the sun's disc' (Knight 1933).

For the time being, the ship had no commander and, more importantly, no specific location in the southern hemisphere for observing the astronomical event. In the discussions leading to the drafting of the memorial, however, suggestions were made that one of the Marquesas Islands, which had been sighted by Alvaro Mendaña in 1595, or one of two islands in Tonga (then named Rotterdam and Amsterdam Islands and last seen by Abel Tasman in 1643), might be suitable, but no one was certain precisely where in the ocean these likely candidates were (Beaglehole 1955).

While the issue of the ship's destination remained unresolved, that of the *Endeavour*'s commander was moving along swiftly. Sometime during the week after the order to get the ship ready for sea, that is before mid –April 1768, the Admiralty found in James Cook the man that they wished to appoint to command. Cook was not a young man and, as far as the Royal Navy was concerned, fairly inexperienced but he certainly had talent (Beaglehole 1962). He was born in Yorkshire and first went to sea when he was eighteen years old working for a Whitby company carrying coal from northeast England to London. Once Cook's apprenticeship was over he sailed on ships throughout the North Sea, from Holland in the south to Norway in the north. He did well, and he was promoted but then, and for no reason that has come down to us, he volunteered, in 1755, to join the Royal Navy in Wapping, east London. Two years later he became a master, qualified, therefore, to sail naval ships. By then however, war had erupted between Britain and France and their respective allies and Cook was sent on a naval squadron to North America where he participated in several battles in and around the St. Lawrence River. When in 1763, peace came, bringing an end to what was then referred to as the Seven Years' War, Cook, who had by now distinguished himself in surveying and cartography, in addition to navigation, was appointed to be the surveyor on a naval expedition to Newfoundland over which Britain had been given sovereignty under the terms of the peace treaty. There he remained, apart from short spells back in London, until the early part of November 1767, when he returned bearing a cache of elegantly produced maps and hydrographic surveys of the coasts of this geographically complicated island.

Cook intended to return to Newfoundland in the spring of 1768, once he was satisfied that the engravers were competently handling his manuscript maps, but this is not what happened. His requisitions to the Admiralty to prepare his surveying ship for the next season coincided precisely with their search for someone to command HMS *Endeavour*. Cook never crossed the north Atlantic again. Instead, from now until his murder in Hawaii in February 1779, his life was bound up wholly with the Pacific.

It was now May 1768. The *Endeavour* was being prepared but where was it heading? Cook, and Charles Green, whom the Royal Society had already appointed as the expedition's astronomer, were the designated observers. They needed an island on which they could erect their observatory. Would Cook be able to find the Marquesas or Amsterdam and Rotterdam island? And if he could, would the ship be welcomed or attacked?

While these questions were being discussed in the Admiralty and the Royal Society, something wholly unexpected happened (Williams 1998). On 20 May 1768, Samuel Wallis, a naval commander, arrived in London with scarcely believable news. In August 1766, Wallis had been given command of HMS *Dolphin* whose objective was to sail into the Pacific in search of *Terra Australis Incognita*, the substantial land mass that was supposed to exist in southern latitudes –Alexander Dalrymple, the noted hydrographer and cartographer, preferred to use the term 'Southern Continent' and many followed his example (Cock 1999; Patel 2016; Williams 1996). Wallis reported that high land had been seen in the distance during the voyage but what caught his and everyone else's imagination was his discovery of an extraordinary island and civilization, to which he gave the name, in honour of his sovereign, of 'King George the Third's Island' (Salmond 2010). Wallis was an excellent navigator and equipped with the latest instruments to calculate that most elusive of navigational parameters –longitude. He reported that this island, which had abundant food and water, a healthy climate, a good anchorage and welcoming people, and which we now know as Tahiti, lay at 17 degrees 30 minutes latitude and 150 degrees longitude, west of London, precisely within Maskelyne's oceanic rectangle.

Wallis knew nothing about the Royal Society's interest in tracking Venus and the Admiralty did not expect him to arrive in London for at least a year, in other words, sometime in 1769. As it happened, because of widespread illness among his crew, his own weakness and serious doubts that his ship could stand any more wear and tear, Wallis had decided to abandon a part of his surveying objectives and hurry home by way of the Cape of Good Hope – in spite of his instructions to return by way of Cape Horn (Patel 2016).

Wallis's discovery of the island and of an excellent anchorage in the very north of the island, at a place he named Port Royal, or Matavai Bay in Tahitian, where he anchored on 23 June 1767, could not have been better news for the Royal Society. The vague destination of the Marquesas and Tonga was now replaced by a firm, precise and, therefore, perfectly findable location. The predicted date of the transit was almost the same as the date of Wallis's anchorage so that what he described then, especially the weather, would equally apply to the *Endeavour*'s stay. On 9 June 1768, a fortnight after Cook had officially taken charge of the *Endeavour*, the Council of the Royal Society endorsed the choice of the island discovered by Wallis as the expedition's destination (Beaglehole 1955; Knight 1933). In the following month, the Admiralty reaffirmed the Society's decision of where to observe the track of Venus when they presented their instructions to James Cook, who had, in the meantime, been promoted to the rank of lieutenant (Beaglehole 1955). To guide him to Tahiti, the Admiralty presented Cook with copies of 'such Surveys, plans and Views of the Island and Harbour as were taken by Capt Wallis, and the Officers of the Dolphin when she was there' (Beaglehole 1955).

The Royal Society Council meeting minute of 9 June 1768 recorded the important concrete decisions that had been taken since the 'Memorial' of mid –February in order to effect this astronomical expedition: the observers, Cook and Green, had been chosen and their salaries agreed; the ship and its commander had been commissioned; and the location in Maskelyne's rectangle of southern sea, pinpointed.

At this point, the scientific aspects of Cook's expedition to the Pacific were astronomical and geographic. Had the expedition remained this way, then Madeira would not have played any significant role in this story. This was the first of the two tipping points. Instead of the narrow focus of the expedition, it broadened in almost no time at all and in unexpected directions.

What happened was this. The minute of the Royal Society's Council meeting which recorded Cook and Green's appointment, also had a small note to the effect that the Society's secretary would be asking the Admiralty that 'Joseph Banks... being desirous of undertaking the same voyage... for the Advancement of useful knowledge... He... together with his Suite... be received on board of the Ship, under the Command of Captain Cook' (Beaglehole 1962; Beaglehole 1955). The purpose of the expedition was about to be completely redefined and Banks was solely responsible for that.

Who was Banks and how did he find himself in this position? Banks was born on 13 February 1743 in London. His formal education began at the age of nine following a curriculum primarily in Latin, Greek and English literature, which he studied dutifully but without much enthusiasm or success. When he was seventeen years old, he enrolled at Christ Church, Oxford. During his first year at the university, Joseph's father William died. When he came of age in 1764, Banks inherited his father's extensive estates and thus became an extremely wealthy young man.

Banks continued to attend university and during his time there he became intensely interested in natural history. To get some kind of formal instruction in botany –the subject was not on the curriculum at Oxford– Banks, who now had money to spend, paid to be present at a set of lectures on botany delivered during the summer of 1764 to a group of sixty enthusiastic students by Israel Lyons, a Cambridge botanist and astronomer (Glyn 2002). Lyons was one of the earliest exponents of the new Linnaean system in Britain and shared his understanding of and passion for it with Banks.

Banks left Oxford without a degree shortly after Lyons's lectures. He could have done anything he liked –gone into the law, church, or the City– or simply enjoyed himself as a wealthy young man about town, but his great enthusiasm was for plants. As soon as he could he moved to Bloomsbury close by the newly-opened British Museum, with Sir Hans Sloane's collection at its core, to which he obtained a reader's ticket on 3 August 1764, and there he threw himself into the study of botany, helped by its world–famous herbaria, illustrations and texts.

At that time, the British Museum was the only public space in London where natural history could be studied. While he was there, Banks became acquainted with others like himself, and through his new contacts and friendships, he was elected a Fellow of the Royal Society on 1 May 1766, aged twenty-three.

Like every enthusiastic naturalist, Banks went out and about botanizing, observing and collecting living specimens in their habitat. A rare chance to botanize beyond Europe came Banks's way in April 1766, when an old school friend, Lieutenant Constantine Phipps, invited him to join HMS *Niger* bound for fisheries duty in Newfoundland and Labrador, which Banks eagerly accepted.

The *Niger*, with Banks aboard, was away from England for nine months, from 22 April 1766. Six of those months were spent in and around Newfoundland and Labrador. Though he and James Cook were in the same harbour on 27 and 28 October 1766, there is no evidence that they met on this occasion (Carter 1988). Coming home by way of Lisbon on 26 January 1767, Banks landed with a substantial haul of new natural specimens –plants, birds, insects and fishes– many of them new to European science and all of which needed to be classified and some of which illustrated.

Banks attended his first Royal Society meeting on 12 February 1767 shortly after his return from Newfoundland and Labrador (Carter 1988). Though he was not in London when, in November 1767, the Committee of the Transit recorded its decisions about how the Society wished to have Venus's track observed, it is very likely that he knew about it shortly thereafter and certainly by the time of the 'Memorial' to the King on 15 February 1768, Banks had made up his mind to try and join the expedition (Carter 1988). Over the next few months, by dint of careful negotiations and relationships, especially with Philip Stephens, the First Secretary of the Admiralty, whom he had met at the British Museum, Banks convinced those in authority that he should be go to the South Seas (Carter 1988). The Royal Society Council minute of 7 June 1768, requested the Admiralty to accept Banks, accompanied by seven others, including two artists, a secretary and a team of assistants and servants, all paid for by him (a critical consideration), to join the ship (Carter 1988; Cook 2004).

On 22 July the Admiralty informed Cook that the Royal Society's request had been accepted, but, instead of seven in Banks's accompanying suite, they now stipulated that eight, in addition to Banks, would be going (UK National Archives, ADM2/94, 22 July 1768).

Not far from the Reading Room where Banks immersed himself in the British Museum's natural history riches, Daniel Solander, Linnaeus's best and favourite student, who, in 1763, had been invited to England, especially by the botanist John Ellis, to expound his teacher's new system of classification, was busily working on cataloguing the Museum's natural history collections. A year after arriving in London Solander was made a Fellow of the Royal Society (Duyker 1998).

Ten years Banks's senior, Solander took over the latter's botanical education where Lyons had left it off. Solander had prepared Banks for the Newfoundland voyage and when he returned, Solander helped him catalogue the plants that had been collected (this and the following is taken from Chambers 2007, 16 November 1784). It is not surprising, therefore, that Banks confided in Solander that he was planning to join the *Endeavour* –he was 'very excited by my plans, and immediately offered to furnish me with information on every part of natural history which might be encountered on such an ambitious and unparalleled mission', Banks later remarked. It was several days later when they were dining at the home of a mutual friend, that the topic of the *Endeavour* came up and, according to Banks, Solander jumped to his feet and asked Banks if he wanted a companion to join him. Banks replied, 'Someone like you would be a constant benefit and pleasure to me!'. Solander did not hesitate. 'I want to go with you', he exclaimed.

On 24 June 1768 Solander wrote to the Trustees of the British Museum telling them about Banks's offer. Solander added that this unique opportunity would allow him to collect for the Museum (Duyker and Tingbrand 1995, 24 June 1768 and 1 December 1768). They agreed to his leave of absence. Banks may have been well known in the Royal Society, and in the British Museum's Reading Room, but in the world of botany, it was Solander who was the more famous. He was a key addition to the voyage.

This was now quite a different expedition from what had been in the Royal Society's mind when they petitioned the King for financial help. It wasn't just advances in astronomy and geography that would hopefully flow from the expedition but now, natural history, and in particular botany, had a leading role. There were also now two fellows of the Royal Society on board, giving the expedition the highest scientific credentials.

John Ellis, the botanist who had been instrumental in inviting Solander to London and who had known Banks since 1764, wrote to Linnaeus telling him about the forthcoming voyage (Carter 1988; Linnean Society, Linnean Correspondence, 19 August 1768). Ellis's main message to Linnaeus was that his student, Daniel Solander, was accompanying Joseph Banks, whom he described as a very wealthy man, to the South Seas. Ellis added that they were very well –equipped, with a fine library and all of the tools necessary to collect and preserve natural history specimens; or, in Ellis's own words– 'No people ever went to Sea better fitted out for the purpose of Natural History, nor more elegantly'. What Ellis did not mention was the huge quantity of cases and book-shelving that Banks was taking on board –'such a Collection...as almost frighten me' Banks remarked (Chambers 2008–

Revista Scientia Insularum, 3; 2020, pp. 27-38

2014, 16 August 1768). Banks and his suite were given rooms next to Cook's. The 'scientific gentlemen' would be sharing his great cabin, specimens in bottles and in presses, nets and hooks, and sheets of drawing paper jammed up next to maps and mathematical instruments (Chambers 2008–2014, 18 August 1768). Deferentially, Ellis concluded his letter to Linnaeus by saying that 'All this is owing to you and your writings'.

On 30 July 1768, Cook received his instructions. He was to take the ship to Port Royal Harbour by way of Cape Horn. On the way, the Lords of the Admiralty remarked, 'You are at Liberty to touch upon the Coast of Brazil, or at Port Egmont in Falkland Isles, or at both in your way thither'. The first stop though was Madeira, where Cook was ordered to 'take on board such a Quantity of Wine as you can Conveniently stow for the use of the [Ship's] company' (Beaglehole 1955). And so, on 25 August, the *Endeavour*, with almost one hundred men on board, ten of whom had already been to the Pacific on the two previous voyages of HMS *Dolphin*, and had already been to Madeira, left Plymouth for the Pacific Ocean.

Now the second tipping point. Considering what Madeira had to offer Cook in the way of vital supplies, its choice as the first destination was reasonable, but it could just as easily have been Tenerife as it was for other naval and merchant ships. Where a ship is concerned, nothing is set in stone: contrary winds, or inclement weather, or sudden shipboard illnesses could easily have made Cook steer for another location for wine supplies –the decision was entirely his. As it turned out, the weather was kind and the crew in excellent shape.

As soon as Banks learned about the stop in Madeira, he would have begun acquainting himself with examples of the island's flora as they were represented in the British Museum's herbarium, essentially the herbarium that had belonged to Sloane and on which Solander was working (Carter 1988).

On 12 August 1768, at about ten in the evening, HMS *Endeavour*, came to anchor in Funchal's semi-protected harbour as planned, next to HMS *Rose*, on its way to North America, and several merchant ships. Banks and Solander had already begun collecting and Sydney Parkinson drawing as the ship had slowly made its way southward (Chambers 2008-2014, 1 December 1768). Now, and for the first time, they could extend their practices to include plants.

'This country is very mountainous', Sydney Parkinson noted in his journal, 'yet it is cultivated to the very tops of the mountains; and, being covered with vines, citrons, oranges, and many other fine fruit-trees, it appears like one wide, extended, beautiful, garden (Parkinson 1784).' It was not the best time of the year to collect yet by the end of their five days' stay, over 300 species of plants, many of which were cultivated, had been collected –Solander reported to Linnaeus that of these 50 or 60 were new species (Beaglehole 1962; Duyker and Tingbrand 1995, 1 December 1768). Thomas Cheap, a prominent Madeira wine export merchant and English consul on the island, offered Banks and Solander horses and guides but if these were used, it was not intensive since the radius of collection did not exceed 5 kilometres (Beaglehole 1962). Cheap was generous –he also offered Banks and Solander his house, which they accepted– but it was Thomas Heberden, the resident physician, who proved more useful (Heberden 1990). Heberden, who had been on the island for twenty years (he had also spent seven years on Tenerife before that), had a distinct scientific bent and had been elected to the Royal Society in 1761. Both Banks and Solander would have known about him since he had had several of his scientific papers published in the Royal Society's *Philosophical Transactions* in the 1750s and 1760s. Solander thought he was a very accomplished naturalist and 'very communicative', and that his Royal Society connections gave him much caché, 'the oracle of the Island', as he referred to him (Duyker and Tingbrand 1995, 1 December 1768). Both Banks and Solander made their appreciation of his help known to their correspondents in London.

Cook was ready to leave. He loaded the ship with water, onions and beef and almost 14,000 litres of the finest Madeira wine. This may sound excessive but once the number of drinkers and the length of time expected at sea and distant from another supply of wine is taken into account, it is not as great as all that. They set sail for Rio de Janeiro on 18 September 1768.

The time to cross the Atlantic (it took almost two months) was used by Banks, Solander and Parkinson (and perhaps also by the other two artists/naturalists accompanying them, Alexander Buchan and Herman Spöring) to classify and produce colour drawings of some of the specimens (Rose 2018; Duyker and Tingbrand 1995, 1 December 1768). One of these, a plant which Solander referred to as *Heberdenia excelsa*, in the family Primulaceae, was certainly completed in this manner.

Madeira was significant to the Banksian suite because it was the first time they were able to try out a system which, if successful, they intended to use throughout the expedition: namely to collect, describe and classify, with a Linnaean and, if possible, a local name, to draw and to preserve (a fuller discussion of this aspect of the voyage can be found in Francisco-Ortega *et al.* 2015a and Francisco-Ortega *et al.* 2015b). But Madeira was important in another way too.

As John Ellis pointed out in his letter to Linnaeus, Banks had a library with him. Unfortunately, there is no list of the titles, but about seventy of them have been deduced (Carter 1988; Carr 1983). Of course, and it is no surprise, there was a copy of the second edition of *Species Plantarum*. It is not, however, the presence on board of this book that is significant for our understanding of the history of researches into Madeira's botany, but rather it is the presence of Hans Sloane's *Voyage to the Islands*, *Madera*, *etc*., which requires a moment of reflection.

Sloane was in Madeira for a few days in 1687 on his way to the Caribbean and made a significant collection which he recorded on two occasions, once in 1696 and the other, more significantly, in his two –volume narrative of his travels, published in 1707 (Menezes de Sequeira *et al.* 2010; Francisco-Ortega *et al.* 2010; Delbourgo 2017).

Sloane's plant collection (as well as those of others Sloane acquired) was organized according to John Ray's system and it was Solander's task to reclassify it according to the newer Linnaean system (Rose 2018). This Solander began to do soon after early March 1763. To help him produce a catalogue of the first few volumes of Sloane's herbarium, Solander used a clean copy of Sloane's *A Voyage*, which Joseph Banks provided for him, transferring Sloane's annotations, from his own copy that he had bequeathed to the Museum, and adding the Linnaean names mostly from the 1762-3 edition of *Species Plantarum*.

Sloane's *A Voyage*, annotated and revised by Solander, was brought to Madeira in September 1768. It must have been a special moment. Solander, Linnaeus's student, holding Banks's copy of a book written by Hans Sloane, the founder of the British Museum, with the first published description of Madeiran plants, now revised for the new botanical age.

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JAMES COOK AND MACARONESIAN BOTANY: TYPIFICATION AND NOMENCLATURE UPDATES OF THE NEW SPECIES DESCRIBED BY JOHANN R. FORSTER AND J. GEORG A. FORSTER

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Abstract

Johann Reinhold Forster and his teenaged son John Georg Adam Forster (then 17) joined James Cook's second voyage (1772-1775), as botanist and artist, respectively. Upon their return they described six species that are pertinent to the study of the Macaronesian flora. Previous typifications are revisited and we designate lectotypes for *Aytonia rupestris* J.R. Forst. & G. Forst. (Aytoniaceae), *Borago tristis* G. Forst. (Boraginaceae), and *Teucrium canescens* G. Forst. (Lamiaceae). We designate epitypes for *A. rupestris* and *Epibaterium pendulum* J.R. Forst & G. Forst. Our study indicates that *Teucrium betonicifolium* Jacq. is the accepted name for this Madeiran endemic. Lectotypes, along with epitypes, are also designated for *T. betonicifolium* and *T. betonicum* L'Hér.

Keywords: botanical history, Atlantic islands, plant taxonomy, botanical exploration, the Enlightenment.

JAMES COOK Y LA BOTÁNICA MACARONÉSICA: NOTAS NOMENCLATURALES DE LAS NUEVAS ESPECIES DESCRITAS POR JOHANN R. FORSTER AND J. GEORG A. FORSTER

Resumen

Johann Reinhold Forster y su hijo John Georg Adam Forster (entonces con 17 años) se unieron, respectivamente como botánico y artista, al segundo viaje de circunnavegación de James Cook (1772-1775). Aquí proporcionamos un estudio nomenclatural de las seis nuevas especies que ellos describieron para la Macaronesia. Se revisan tipificaciones anteriores y designamos lectotipos para *Aytonia rupestris* J.R. Forst. & G. Forst. (Aytoniaceae), *Borago tristis* G. Forst. (Boraginaceae) y *Teucrium canescens* G. Forst. (Lamiaceae). Designamos epitipos para *A. rupestris* y *Epibaterium pendulum* J.R. Forst & G. Forst. Nuestro estudio indica que *Teucrium betonicifolium* Jacq. es el nombre que se debe aceptar para este endemismo de Madeira. También se designan lectotipos con epitipos para *T. betonicifolium* y *T. betonicum* L'Hér.

Palabras clave: historia de la botánica, islas atlánticas, taxonomía vegetal, exploración botánica, la Ilustración.

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1. INTRODUCTION

The *FloraMac2018* international meeting provided an opportunity to celebrate the 250th anniversary of the visit made by James Cook to the island of Madeira in September 1768 during his famous first voyage aboard HMB *Endeavour*. During this expedition Cook had the Navy rank of Lieutenant being promoted to Commander in his second circumnavigation voyage (Barlass 2018). Cook was accompanied by the botanist Joseph Banks, who would become one of the great patrons of natural sciences and by Daniel Solander, a disciple of Linnaeus and Assistant Librarian at the British Museum, responsible for cataloguing the natural history collections. From Madeira, the expedition continued to Brazil, Tierra del Fuego, the South Pacific, New Zealand and Australia before returning to The Downs (England) on July 1771 via Java, the Cape and St Helena (Obeyesekere 1992). Two additional extensive oversea voyages led by Cook made visits to Macaronesia: during his second voyage he called at Madeira, Santiago (Cabo Verde), and Faial (Azores); whilst during his third voyage he called at Tenerife (Canaries). The second circumnavigation (1772-1775) also had a strong botanical component because Johann Reinhold Forster and his son John Georg Adam Forster (then 17) joined the expedition as botanist and artist, respectively (Bodi 1959). Upon their return to Europe, these two German naturalists published many species based on the material that they had collected and recorded during the three-year expedition.

Two of the taxonomic contributions published by the Forsters are important to our research. One of them focused on the many plants that were recorded during the journey [titled as *Characteres generum plantarum* in *Taxonomic Literature 2* (Stafleu and Cowan 1976)] whereas the second work (Forster 1788) provided what we believe was the first published floristic catalogue for Atlantic oceanic islands. This catalogue provided a list of plants that were found on the islands of Ascension, Faial,

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Madeira, Saint Helena, and Santiago. A bibliographic note regarding the effective publication date of species published in these two contributions is needed.

Characteres generum plantarum was the first book published by the Forsters upon their arrival in Britain (Nicolson and Fosberg 2004; Earp 2013). It had three editions (Forster and Forster 1775, 1776a, 1776b); however, only three copies are known for the 1775 edition (Earp 2013). One of the editions produced in 1776 is known as the "common 1776 quarto edition" (Forster 1776a), the other as the "folio copy" edition (Forster 1776b). The former is also referred as the "Second edition" and it is the most widely distributed one (Stafleu and Cowan 1976). All three 1775-1776 versions are identical with regards their plant plates and the described species (Earp 2013). The last International Botanical Congress (Shenzhen, China) resolved that 1776 is the effective publication date (in the "common 1776 quarto edition") for species published in this book as the 1775 version is only available in three libraries (The Linnean Society of London; the State Library of Victoria, Australia; and the King's Library at the British Library). We follow this decision below.

As originally issued the catalogue of Atlantic island plants, authored by Georg Forster, was published in a work entitled *De plantis magellanici et atlanticis commentationes* that had two chapters (fig. 1), viz., 1) *Fasciculus plantarum magellanicarum* (pp. 1-33, t. 1-8), which focused exclusively on those plants that were recorded in Tierra del Fuego; and 2) *Plantae Atlanticae ex insulis Madeira St. Jacobi Adscensionis Stae Helenae et Fayal reportatae* (pp. 34-62). They also form parts of volume 9 of the journal *Commentationes Societatis Regiae Scientiarum Gottingensis* (9: 13–74. 1789 ("1787"), fig. 1). There has been conflicting information regarding the date of the publication of the catalogue. Stafleu and Cowan (1976: 859) listed the following in *Taxonomic Literature 2*:

> *Fasciculus plantarum magellanicarum*... *Publ*.: 1787 after 18 Sep, date of presentation (see p. 13 of publ. in Comm.), p. [1]-64, *pl. 1-8. Copy*: M.- Reprinted from Comm. Soc. Goett. 9: 13-74, *pl. 1-8.*1787 (*Copy* MO).- The M copy has a t.p. on [1]: "Georgii Forster, M.D. cet. *De plantis magellanicis et atlanticis commentationes*." This is apparently the special t.p. for the independently paged reprint. The full heading of the journal article (on p. 13) is "*Fasciculus plantarum magellanicarum* oblatus societati in ipso consessu sollennium Academiae Georgiae augustae semisaecularim d. xviii Sept mdcclxxxvii." This is followed on p. 46 by "Plantae atlanticae ex insulis Madeira, St. Jacobi, Adscensionis, St. Helena et Fayal reportatae."

Although Stafleu and Cowan (1976: 859) listed the date of publication of this catalogue as "1787 after 18 Sep," the title page and preface of volume 9 show the date as 1789. In contrast, Nicolson and Fosberg (2004: 65) treated Georg Forster's work as a preprint issued in March-April 1788 that was published under the title "*De plantis magellanicis et atlanticis commentationes*" (fig. 1). Nicolson and Fosberg (2004: 57) mentioned that they had not seen a copy of the preprint; however, they stated the following:

> ... thanks to Prof. G. Wagenitz (pers. comm.) it is now established that there was a separately paged preprint that appeared between 16-17 Jan 1788, when extant

GEORGII FORSTER, M. D.
CET.
DE
PLANTIS
MAGELLANICIS ET ATLANTICIS
COMMENTATIONES.

COMMENTATIONES
SOCIETATIS REGIAE SCIENTIARVM
GOTTINGENSIS
AD A. CIↃIↃCCLXXXVII ET LXXXVIII.
VOLVMEN IX.
CVM FIGVRIS.
GOTTINGAE
APVD IOANN. CHRIST. DIETERICH.
CIↃIↃCCLXXXIX.

GEO. FORSTER
SOC. REG. SCIENT. GOTTINGENS. SODALIS,
FASCICVLVS
PLANTARVM MAGELLANICARVM
OBLATVS SOCIETATI
IN IPSO CONSESSV SOLLENNIVM
ACADEMIAE GEORGIAE AVGVSTAE
SEMISAECVLARIVM
D. XVIII. SEPT. MDCCLXXXVII.

46 GEO. FORSTER

GEO. FORSTER
SOC. REG. SCIENT. GOTTINGENS. SODALIS,
PLANTAE ATLANTICAE
EX INSVLIS MADEIRA STI IACOBI ADSCENSIONIS
STAE HELENAE ET FAYAL REPORTATAE.

Figure 1. Bibliographic details pertinent to G. Forster's publication on the flora of Atlantic Islands where he described new Macaronesian species for Cabo Verde and Madeira. Top left: Cover of preprint published between March and April 1788 (courtesy of *Georg-August-Universität Göttingen*, SUB Goettingen, call number: 8 BOTV, 9220). Top right: Cover of volume 9 of *Commentationes Societatis Regiae Scientiarum Gottingensis*, year 1789. Bottom left: First page of article on Tierra del Fuego plants as it was published in volume 9 of *Commentationes Societatis Regiae Scientiarum Gottingensis*. Bottom right: First page of article on Atlantic Island plants as it was published in volume 9 of *Commentationes Societatis Regiae Scientiarum Gottingensis*. Images from volume 9 of *Commentationes Societatis Regiae Scientiarum Gottingensis* are public domain (https://archive.org/details/bub_gb_BigC_3BYCdMC/page/n4; document provided by the *Biblioteca Nazionale Vittorio Emanuele III*, Naples).

letters from George refer to offprints then being printed, and a 13 May 1788 letter from George that refers to some copies of the offprints accidentally having been left behind in Frankfurt by his servant. It can be presumed that these preprints were distributed by March or April 1788.

It is noted here that in the absence of internal evidence, external evidence may be used to determine the date of a publication, and the extant letters from Georg Forster conserved at GOET [herbarium institutions are coded as indicated in Thiers (2019)] serve as such an evidence (cf., Art. 46.9).

Without referencing to Nicolson and Fosberg's (2004: 57) remarks, Dorr and Nicolson (2008: 329) mentioned that "Forster's article was published shortly before 23 May 1789" in *Commentationes Societatis Regiae Scientiarum Gottingensis*.

Thus, three different years have been given for species published in this work: 1787 (e.g., Abedin 1979), 1788 (e.g., Nicolson & Fosberg 2004), and 1789 (e.g., Fryxell 2002). Since the status of "Georgii Forster, M.D. cet. *De plantis magellanicis et atlanticis commentationes*" as either a preprint (dated 1788) or independently paged reprint (dated 1789) has been disputed, we consulted Dr. Laurence J. Dorr (US). Dorr kinly clarified the situation stating that the serial publication is dated 1789 and that a review indicates that Forster's article was available by 23 May 1789. Furthermore, Dorr suggested that copies of G. Forster's work conserved at Göttingen and Munich need to be examined.

Subsequent requests to Dr. Hans-Joachim Esser (M) and Dr. Marc S. Appelhans (GOET) confirmed the independent pagination of their library copies of "Georgii Forster, M.D. cet. *De plantis magellanicis et atlanticis commentationes*." However, neither copy has the date of publication or of receipt by the relevant libraries. Dorr (pers. comm.) remarked that although internal evidence for the publication date of the preprint is lacking, there is sufficient external evidence to argue that the names appeared in 1788 (see above). In this regard, Dorr (pers. comm.) concurred with Nicolson and Fosberg (2004: 57) and we accept Dorr's assessment. With reference to Stafleu and Cowan's (1976: 859) treatment of Georg Forster's work as a reprint, we speculate that Stafleu and Cowan erred in believing that the Forster article in the journal (pp. 13-74) was published after 18 September 1787 and eventually as an independently paged "reprint" (pp. 1-64). Obviously, they were not aware that the journal article was published shortly before 23 May 1789 and that the independently paged Forster article could be a preprint published in 1788.

Among the taxonomic contributions made by the Forsters, there were four new species that were described based on Macaronesian specimens by Georg Forster (1776a, 1788, table 1), one of them was collected in Madeira (*Teucrium canescens* G. Forst.) and the remaining three came from Cabo Verde (*Antirrhinum elegans* G. Forst., *Borago tristis* G. Forst., and *Sida pannosa* G. Forst.). Furthermore, two additional species (*Aytonia rupestris* J.R. Forst. & G. Forst and *Epibaterium pendulum* J.R. Forst. & G. Forst) are also relevant to our research. These two species were described by Forster and Forster (1776a) without any precise locality in the three editions of *Characteres generum plantarum*. An indication of the provenance of *Epibaterium pendulum* as Santiago, Cabo Verde was, however, provided in two other sources. The first was by Forster (1788), a published account with a long species description; the second was a watercolor made by Georg Forster (housed in BM) that was recently published by Romeiras *et al*. (2014). Regarding *Aytonia rupestris*, the only details regarding its distribution was made by Forster (1788) who indicated that this liverwort was found in Madeira in "locis umbrosis humidis, ad saxorum crepidines secundum torrentium decursum." Although, in the original description by Forster and Forster (1776b) it is not stated where these two species were actually located, it is clear from Forster (1788) that they were found in Macaronesia.

Our research provides a nomenclature update for these six species (see table 1 with accepted names) that the Forsters recorded in Macaronesia during Cook's second voyage and subsequently were described by them.

TABLE 1. NATIVE SPECIES FROM MACARONESIA DESCRIBED BY JOHANN R. FORSTER AND GEORG FORSTER

Name as originally published	Accepted name	Family	Island[1]	Publication
Antirrhinum elegans G. Forst.[2]	*Nanorrhinum elegans* (G. Forst.) Ghebr.	Plantaginaceae	CV	Forster (1788)
Aytonia rupestris J.R. Forst. & G. Forst.	*Plagiochasma rupestre* (J.R. Forst. & G. Forst.) Steph.	Aytoniaceae	M	Forster and Forster (1776a)
Borago tristis G. Forst.	*Trichodesma africanum* (L.) Lehm	Boraginaceae	CV	Forster (1788)
Epibaterium pendulum J.R. Forst. & G. Forst.	*Cocculus pendulus* (J.R. Forst. & G. Forst.) Diels in Engler	Menispermaceae	CV	Forster and Forster (1776a)
Sida pannosa G. Forst.	*Abutilon pannosum* (G. Forst.) Schltdl.	Malvaceae	CV	Forster (1788)
Teucrium canescens G. Forst.[3]	*Teucrium betonicifolium* Jacq.	Lamiaceae	M	Forster (1788)

[1] Cabo Verde is coded as CV, Madeira is coded as M. Notice that Santiago was the only island visited in Cabo Verde by the Forsters.
[2] Cabo Verde endemic.
[3] Madeira endemic.

Nicolson (1998), and Nicolson and Fosberg (2004) catalogued the hundreds of watercolors that Georg Forster made for many of the plants that were recorded or collected along the voyage. This artwork is scattered in seven museums/libraries, and for the most part has remained unpublished. Five of the six species studied in our contribution (i.e., *Abutilon pannosum*, *Cocculus pendulus*, *Plagiochasma rupestre*, *Teucrium betonicifolium*, and *Trichodesma africanum*) to this *FloraMac2018* special issue were depicted in Forster's paintings and drawings (Romeiras *et al*. 2014: fig. 7; Francisco-Ortega *et al*. 2015: figs. 10-14. Reviewed by Romeiras *et al*. 2014: table 1 and by Francisco-Ortega *et al*. 2015: table 1). Interestingly, for *Aytonia rupestris* and *Epibaterium pendulum*, the illustrations were part of the original species descriptions made by Forster and Forster (1775). In order to further reveal the artwork of Macaronesian plants made by Georg Forster, in our contribution we present copies of his watercolors for *Abutilon pannosum* (housed in Gotha Library, Thuringia, Germany) and *Plagiochasma rupestre* (housed in BM). Since the time of their making, both drawings have remained unpublished (see figs. 2-3).

The taxonomic contributions of the Forsters have historical significance as they were the first naturalists to undertake field work in Macaronesia and subsequently publish binomial names for the flora of these islands. Other well-known botanists (e.g., Joseph Banks, João Feijó, Francis Masson, Daniel Solander, James Robertson, George Staunton) collected in the islands during the late 18th century, but none described any species for the region [reviewed by Francisco-Ortega *et al.* (2010) and Romeiras *et al.* (2014)]. Daniel Solander prepared a flora for Madeira

Figure 2. Watercolor of *Plagiochasma rupestre* (J.R. Forst. & G. Forst.) Steph. (Aytoniaceae) made by Georg Forster, based on material recorded in Madeira during the second voyage of Cook. Image copyright of the Natural History Museum of London.

Figure 3. Watercolor of *Sida pannosa* G. Forst. (Malvaceae) made by Georg Forster, based on material apparently recorded in Cabo Verde Islands during the second voyage of Cook. Image copyright of the Gotha Library, Thuringia, Germany.

that remained unpublished as an incomplete manuscript housed at BM (Britten 1904; Francisco-Ortega *et al.* 2015).

Nicolson and Fosberg (2004) made a remarkable revision pertinent to all known specimens collected by the Forsters during the second voyage of Cook. Their work was pivotal for our research as it provided the necessary framework to locate putative type material. Furthermore, Nicolson and Fosberg's (2004) publication also has details regarding typifications previously made for names published by the Forsters. Pertinent to our research, Nicolson and Fosberg (2004) identified typifications that were made for *Antirrhinum elegans* and *Sida pannosa* by Sutton (1988) and Abedin (1979), respectively. However, they did not mention the neotypification of *Aytonia rupestris* performed by Bischler and Sérgio (1984) or the work published by Troupin (1956) in which it was indicated that the holotype of *Epibaterium pendulum* was identified. Therefore, among the six names that we included in our study only two of them, *Borago tristis* and *Teucrium canescens*, were not the subject of any previous typifications.

Here we revisit and update the previous typifications made for *Antirrhinum elegans*, *Aytonia rupestris*, *Epibaterium pendulum*, and *Sida pannosa*. Furthermore, we designate lectotypes for *Borago tristis* and *Teucrium canescens*. We follow the latest International Code of Nomenclature (ICN) for algae, fungi, and plants (the Shenzhen code; Turland *et al*. 2018). The names of the six species included in our study are sorted alphabetically below under the genus in which they were originally described by the Forsters. Accepted names are indicated in bold print. Each of the six nomenclature treatments include "Notes" that have additional discussion. Among these six updates, we lectotypify the three names that apply to the Madeiran endemic *T. canescens*. As a working taxonomy for accepted names we follow Duarte (1995), Martins (1995), Ghebrehiwet (2000), Fryxell (2002), Klopper *et al*. (2006), and Sérgio *et al*. (2006). Designated types are listed in table 2, for most of the types there are images available on the internet, and we provide hyperlinks to the websites that have these images (table 2).

TABLE 2. TYPES OF NATIVE SPECIES FROM MACARONESIA DISCUSSED IN THIS STUDY

Name as originally published	Lectotype[1]	Epitype[1]	Isoepitype[1]
Antirrhinum elegans G. Forst.	K000411332		
Aytonia rupestris J.R. Forst. & G. Forst.	Forster and Forster 1776: Plate 74	LISU148993	BM013409477; G00121308; PC771129; PC077134
Borago tristis G. Forst.	BM013399018		
Epibaterium pendulum J.R. Forst. & G. Forst.	BM001125013	LISC128987	BM013731571, A00969309
Sida pannosa G. Forst.	BM000802743		
Teucrium betonicifolium Jacq.	Jacquin 1787: T. 17, Fig. 2 and illustration of single leaf	ORT1057	
Teucrium betonicum L'Hér.	BM013825662	ORT1057	
Teucrium canescens G. Forst.	K001331973		

[1] Herbarium institutions are coded as indicated in Thiers (2019).

2. THE SIX TYPIFICATION AND NOMENCLATURE UPDATES

1. *Antirrhinum elegans* G. Forst., De Plantis Magellanicis et Atlanticis Commentationes: 50, no. 97. Mar-Apr 1788; Commentat. Soc. Regiae Sci. Gott. 9(1): 60, no. 97. 1789 (Plantaginaceae). *Kickxia elegans* (G. Forst.) D.A. Sutton, Revis. tribe Antirrhineae: 211. 1988. ***Nanorrhinum elegans* (G. Forst.) Ghebrehiwet**, Nord. J. Bot. 20: 673. 2000.

Type: "Madeira, in montibus aridis et ad sepes"

Lectotype [designated by Sutton (1988: 212)]: *Antirrhinum elegans* (Forster) Habitat in Madeira, K (K000411332).

Notes: *Nanorrhinum elegans* is a Cabo Verde endemic for which the Forsters appear to have made a single collection (see Nicolson and Fosberg 2004). As discussed by Sutton (1988), it seems that labels from different collections were mixed up and material from this species was assigned to the island of Madeira both in the protologue ("Madeira, in montibus aridis et ad sepes") and on the label of the actual specimen ("Habitat in Madeira"). This specimen was cited as a "holotype" by Sutton (1988). Since Forster did not refer or indicate a type and since it is uncertain that the protologue of *Antirrhinum elegans* was based on a single specimen, Sutton's (1988) citation can be regarded as an inadvertent designation of lectotype, as the name was typified before January 1, 2001. Nicolson and Fosberg (2004) were also of the same opinion.

2. *Aytonia* J.R. Forst. & G. Forst., Char. Gen. Pl., ed. 2: 147. 1776 (Aytoniaceae), nom. rej. vs. *Plagiochasma* Lehm. & Lindenb. 1832 (nom. cons.).

Type: *A. rupestris* J.R. Forst. & G. Forst.

Aytonia rupestris J.R. Forst. & G. Forst., Char. Gen. Pl., ed. 2: 148, t. 74. 1776; G. Forst., De Plantis Magellanicis et Atlanticis Commentationes: 63, no. 170. Mar-Apr 1788 [as "*Aitonia*"]; Commentat. Soc. Regiae Sci. Gott. 9(1): 73, no. 170. 1789 [as "*Aitonia*"]. *Ruppinia rupestris* (J.R. Forst. & G. Forst.) Sw., Meth. Musc.: 122. 1781. ***Plagiochasma rupestre* (J.R. Forst. & G. Forst.) Steph.**, Sp. Hepat. 1: 80. 1898.

Type: See the notes below.

Lectotype (designated here): Forster and Forster (1776): plate 74. Epitype (designated here): Madeira, Quinta do Bom Sucesso, 250-300 m, 12 May 1982, *Sérgio* & *Nóbrega 3873*, LISU (LISU148993). Isoepitypes: BM (BM013409477), G (G00121308), PC (PC0771129 and PC0771134) [Bischler and Sérgio (1984) indicated that a duplicate of this specimen is also found in MADJ; however, it appears that this collection is no longer housed in this herbarium].

Notes: The original description by Forster and Forster (1776) did not provide details of where this species was recorded or collected. Likewise, there are no known original herbarium specimens. The protologue made reference to a single plate that was also published in the same work. Since this plate is an original material, it qualifies to serve as the lectotype. In this regard, the neotype proposed by Bischler and Sérgio (1984) is therefore rejected. As per the Shenzhen Code Art. 9.19(a), Bischler and Sérgio's choice is superseded. However, this plate (number 74) depicts six small fragments/plants, and in order to further clarify the identity of this taxon, our typification also includes an epitype, and in this regard, the specimen that Bischler and Sérgio (1984) designated previously as the neotype is chosen here.

Aytonia is a rejected name in favor of *Plagiochasma* Lehm. (see Turland *et al*. 2018). Forster and Forster (1776) coined the genus name *Aytonia* to honor "Joanne" (= John) Aiton. It is noted here that John Aiton (1711-1798) was the brother of William Aiton 1731-1793; the latter was the superintendent of the Kew Botanical Gardens ("Gardener to his Majesty") during 1759-1793. The remark by Forster and Forster (1776: "Huic Algae nomen dedimus a Joanne Ayton, Observatore curioso, Hortulano primario Regis Magnae Britanniae in horto Botanico

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 39-58

Kewensi") indicates that the genus name *Aytonia* most likely honors William Aiton, and apparently, a typographical error was made by the Forsters regarding the honoree's first name.

3. *Borago tristis* G. Forst., De Plantis Magellanicis et Atlanticis Commentationes: 41, no. 32. Mar-Apr 1788; Commentat. Soc. Regiae Sci. Gott. 9(1): 51, no. 32. 1789 (Boraginaceae).

Type: "S^{ti} Jacobi insula"

Lectotype (designated here): 1 Cape Verd Island: S^{to} Jago. JR & G. Forster [label on back of the sheet]; 1 [label on narrow strip affixing specimen to the sheet], BM (BM13399018).

(=) *Borago africana* L., Sp. Pl. 1: 138. 1753. *Pollichia africana* (L.) Medik., Bot. Beobacht.: 248. 1783. ***Trichodesma africanum* (L.) Sm. in A. Rees**, Cycl. 36(1): *Trichodesma* no. 2. 1817. *Boraginella africana* (L.) Kuntze, Revis. Gen. Pl. 2: 435. 1891. *Borraginoides africana* (L.) Hiern, Cat. Afr. Pl. 1(3): 721. 1898. *Trichodesma africanum* (L.) Lehm., Pl. Asperif. Nucif.: 195. 1818, isonym. *Trichodesma africanum* R.Br., Prodr.: 496: 1810, nom. inval.

Type: "Habitat in Ætiopia."

Lectotype [designated by Kazmi (1971: 519)]: *188.4*, LINN.

Notes: *Borago tristis* is a synonym of *Trichodesma africanum*, a species found both in Cabo Verde and mainland Africa. There is only one known collection of *Borago tristis* made by the Forsters, and it came from Cabo Verde. The collection matches the original description and it is part of a mixed sheet with two collections which is housed at BM. The back of this sheet has a label that helped us to identify Forster's specimen as it states: "1 Cape Verd Island: S^{to} Jago. JR & G. Forster;" and this label matches the locality mentioned in the original description (island of Santiago). The specimen with barcode BM13399018 bears a number "1" on its mounting strip indicating that of the two specimens on the sheet, this is the collection made by the Forsters.

4. *Epibaterium* J.R. Forst. & G. Forst., Char. Gen. Pl., ed. 2: 107. 1776, nom. rej. vs. *Cocculus* DC. 1817, nom. cons. (Menispermaceae)

Type: *E. pendulum* J.R. Forst. & G. Forst., Char. Gen. Pl., ed. 2: 108, t. 54. 1776.

Epibaterium pendulum J.R. Forst. & G. Forst., Char. Gen. Pl., ed. 2: 108. 1776; G. Forst., De Plantis Magellanicis et Atlanticis Commentationes: 59, no. 145. Mar-Apr 1788; Commentat. Soc. Regiae Sci. Gott. 9(1): 69, no. 145. 1789. *Cebatha pendula* (J.R. Forst. & G. Forst.) Kuntze, Revis. Gen. Pl. 1: 9. 1891. ***Cocculus pendulus* (J.R. Forst. & G. Forst.) Diels in Engler**, Pflanzenr. IV.94(Heft 46): 237. 1910. *Cocculus epibaterium* DC., Syst. Nat. 1: 530. 1817 ("1818"), nom. superfl. & illegit. for *Epibaterium pendulum* J.R. Forst. & G. Forst.

Type: See the notes below.

Lectotype [designated by Troupin 1956: 10 (as "holotype")]: Cape Verd Islands. S^{t} Jago Mesrs Forster [label on back of the sheet]; 1 [two labels on narrow strip affixing the specimen to the sheet], BM (BM001125013). Epitype (designated here): Cabo Verde, Porto de S. Francisco, Monte Ilhéu, 10-July-1993, *M.C. Duarte 463*, LISC (LISC128987). Isoepitypes: BM (BM013731571), A (A00969309).

Notes: Troupin (1956) selected a specimen housed at BM (BM001125013) to typify this name. The material that Troupin designated is mounted along with another collection (BM000554342) on a single sheet. A pencil line drawn on the sheet separates these two collections. BM001125013 consists of two sterile individuals; one of them with only a single leaf and the other with five leaves. Troupin annotated the specimen BM001125013 mentioning that it was collected by "Forster" in Cabo Verde. The second collection (BM000554342) was also labeled by Troupin, indicating that it was one of the specimens collected by G. Staunton in 1792, when he was on route to China with the Macartney embassy (Romeiras *et al*. 2014). A label placed on the back of the sheet concords with Troupin's annotations and it confirms that BM001125013 and BM000554342 were collected by the Forsters and Staunton, respectively. Troupin's (1956) citation of the BM001125013 specimen as the holotype is construed here as an inadvertent act of lectotypification as this name was typified before January 1, 2001.

As mentioned before, the lectotype is in poor condition as it has only five leaves. Nicolson and Fosberg (2004) mentioned only one specimen of this species collected by the Forsters, and it is housed in LIV (LIVCM/1909LBG.6431). We are not certain if this specimen is an actual duplicate of BM001125013; however, it is in even worse condition than the lectotype, with only six immature wrinkled leaves. Nicolson and Fosberg (2004) were apparently unaware of the BM specimen and of Troupin's type citation. It is noted here that the plate 54 (Forster and Forster 1775, 1776a, 1776b), mentioned in the protologue, shows one fruit and a few flower parts. In such a situation, although it may seem that the plate should be the preferred choice over the BM specimen for lectotypifying this name, it is not possible to supersede Troupin's inadvertent lectotype designation of an original material (see Art. 9.19), which is not in serious conflict with the protologue. As an alternative, we herewith designate an epitype to complement the sterile lectotype material. We selected a well-preserved specimen collected in Cabo Verde by one of us (MCD) that has well developed reproductive branches with many leaves. This specimen is housed in LISC (LISC128987) with duplicates in BM (BM013731571) and A (A00969309).

The name *Epibaterium* J.R. Forst. & G. Forst. is rejected in favor of the conserved name *Cocculus* DC. (Turland *et al*. 2018).

5. *Sida pannosa* G. Forst., De Plantis Magellanicis et Atlanticis Commentationes: 52, no. 106. Mar-Apr 1788; Commentat. Soc. Regiae Sci. Gott. 9(1): 62, no. 106. 1789 (Malvaceae). ***Abutilon pannosum* (G. Forst.) Schltdl.**, Bot. Zeit. 9: 828. 1851. *Abutilon pannosum* (G. Forst.) Webb, Fragm. Fl. Aethiop.-Aegypt.: 52. 1854, isonym.

Type: "S[ti] Jacobi insula"

Lectotype [designated by Abedin (1979: 74, corrigenda [p. 109] (as "holotype"))]: 1 Cape Verd Islands. S[t] Jago. Mssrs. Forster [label on back of the sheet]; 1 [label on narrow strip holding specimen to the sheet], BM (BM000802743).

Notes: There was some confusion regarding the typification of this name as the initial lectotype assigned by Abedin (1979), in his treatment of *Abutilon* for

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 39-58

the Malvaceae volume of *Flora of West Pakistan* was incorrectly referred to a specimen collected in Senegal (no collector's name was mentioned) housed in MA. Subsequently, a single-page corrigenda was published for the Malvaceae volume of this flora (Nicolson and Fosberg 2004). This short addendum indicated that there was an error regarding the initial typification of *Sida pannosa* made by Abedin (1979). It appears that the sheet containing this corrigendum was sent as a separate document to those who already had the Malvaceae volume of *Flora of West Pakistan*; however, it seems that not all of the available copies of this volume have the corrigenda sheet. For instance, Fryxell (2002), in his revision pertinent to nomenclature of species of *Abutilon*, was not aware of the corrigendum. He mentioned: "TYPE: CAPE VERDE ISLANDS. Insula Sancti Jacobi, G. Forster s.n. (BM). -"described from Senegal (MA)" fide Abedin (1979a)." The corrigenda sheet does not have a page number or an author, but because the Malvaceae volume of *Flora of West Pakistan* was published by S. Abedin, it has been accepted that the corrigenda sheet was issued by Abedin in 1979 and numbered "109" (see Nicolson and Fosberg 2004). The specimen selected by Abedin (1979) for typification is housed in BM (BM000802743). Later, Abedin (1980) confirmed his selection of BM000802743 to typify *Sida pannosa*. This specimen is mounted on a mixed sheet with specimens collected by the Forsters and G. Staunton; the latter also collected from Cabo Verde (see above). However, Forsters's material has a number "1" written on the single strip affixed to the specimen, which matches the information written on the label found on the back of the specimen: "1 Cape Verd Islands. S^{t} Jago. Mssrs. Forster." The collecting site mentioned on this label concords with the locality indicated in the protologue (island of Santiago). Interestingly, BM000802743 was wrongly identified as the holotype of *Sida pannosa* by Abedin (1979, 1980). Here we correct this error and indicate that Abedin (1979) inadvertently lectotypified this name with this specimen.

6. *Teucrium canescens* G. Forst., De Plantis Magellanicis et Atlanticis Commentationes: 48, no. 106. Mar-Apr 1788; Commentat. Soc. Regiae Sci. Gott. 9(1): 58. 1789 (Lamiaceae).

Type: "Madeira, ad torrents"

Lectotype (designated here): *Teucrium canescens* (Forster) Habitat in Madeira, K (K001331973).

(=) ***Teucrium betonicifolium* Jacq.**, Coll. 1: 145, t. 17–2, 1787 [as "*betonic*æfolium"] (Lamiaceae).

Teucrium maderense Lam. Encycl. 2(2): 692. 14 Apr 1788, nom. superfl. & illegit. for *T. betonicifolium* Jacq.

Type: "Colitur in horto Cæsareo Schönbrunnensi"

Lectotype (designated here): Jacquin (1787): T. 17, Fig. 2 and illustration of single leaf without numeration depicted on bottom right side of plate 17. Epitype (designated here): Madeira: Entre Sao Antonio y Curral das Freiras, ca 900 m. Laderas terrosas. Escaso. *E. R. Sventenius 4.VII.1962*. ORT (1057).

(=) *Teucrium betonicum* L'Hér., Stirp. Nov. 4: 83, t. 40. Mar-Apr 1788.

Type: "in Maderâ. Banks & Solander. Masson."

Lectotype (designated here): MADEIRA 1768 BANKS & SOLANDER [typed label], BM (BM013825662). Epitype (designated here): Madeira: Entre Sao Antonio y Curral das Freiras, ca. 900 m. Laderas terrosas. Escaso. *E.R. Sventenius 4.VII.1962*. ORT (1057).

Notes: Jacquin (1787) described *Teucrium betonicifolium* based on the material raised in the Imperial Garden of Schönbrunn, Vienna, from the seeds sent from Madeira. There is evidence from Hooker's (1882: plate 6642) statement that in 1779 Francis Masson, official plant collector of the Royal Botanic Gardens, Kew, sent seeds of Macaronesian plants to Jacquin ("*S.* [Sonchus] *jacquini* is a native of rocky places in the "Laurel region" of the Island of Teneriffe, where it was discovered by Masson, a collector for the Royal Gardens of Kew, who in 1779 sent seeds to the Imperial Garden of Schœnbrun (Vienna), which produced the specimen well figured by Jacquin"). Between 1776 and 1779 Francis Masson visited the Azores, Canaries, and Madeira and sent plant material to Sir Joseph Banks (Francisco-Ortega *et al.* 2010). Therefore, it is likely that the plants of *T. betonicifolium* that Jacquin used to describe this species came originally from a shipment of seeds that he received from Masson. The protologue of this species made reference to "Tab. 17. Fig. 2.". Plate 17, also published by Jacquin (1787), depicted two figures (labeled as "Fig. 1" and "Fig. 2"), and also included an illustration of a single leaf with no labels. A shrub with hairy leaves is shown in "Fig. 1.", and it corresponds to a species also described by Jacquin (1787) as *Arenaria multicaulis* Jacq. (Caryophyllaceae). Based on the description of *T. betonicifolium* and the fact that the painting of this leaf does not match the hairy leaves of the plant illustrated in "Fig. 1," we consider this single leaf to also be part of "Fig. 2" and to belong to *T. betonicifolium*. Jacquin's herbarium is scattered in about 11 institutions, with the core housed in BM (Stafleu and Cowan 1979). These institutions were contacted and we received feedback from all of them except from AWH and CGE. Two sheets of this species are in Jacquin's herbarium in W (sheets 0078940 and 0078941). One of them, 0078941, was collected in Madeira, presumably by the Forsters (see below); therefore, we cannot consider this material as suitable for typification. The second sheet (0078940) has four fragments from two different collections that came from Kew Gardens and from "H-S.". The later refers to Hortus Schönbrunnensis ("H-S."), and therefore can be considered as original material to lectotypify *Teucrium betonicifolium* Jacq. The fragment mounted on the bottom left corner of 0078940 resembles the flowering branch illustrated by Jacquin (1787) that is part of the original description of this species. However, there are no labels that match the four fragments mounted on this sheet to the collections from Kew Gardens or from the Imperial Garden of Schönbrunn. As a result of these uncertainties regarding the material housed in W, we selected the illustration indicated in the protologue as the lectotype of *T. betonicifolium*. Since this plate does not depict details of flowering parts we herewith designate an epitype and choose a specimen housed in ORT (1057) that was collected by E. R. Sventenius (1910-1973), founder of the *Jardín Botánico Canario Viera y Clavijo*. This specimen is also designated as the lectotype of *T. betonicum* (see below).

The description of *Teucrium canescens* indicates that it is a heterotypic synonym of *T. betonicifolium*. During our research, we found one specimen of this species collected by the Forsters in Madeira (K001331973) that was not reported by Nicolson and Fosberg (2004) and it was selected as the lectotype of this name. There is another specimen of this species housed in W (specimen 0078941), which apparently was also collected by them in Madeira. It does not have any annotation referring to the collectors but a label stating: "Teucrium canescens N. Sp. Madeira". According to records found in W it is likely that this is a duplicate of Forsters´s original collection which was given to Jacquin filius during his visit to Göttingen, where many of G. Forster's specimens are housed. Eventually this material passed on to his father´s herbarium at W (C. Bräeuchler pers. comm.).

Regarding *Teucrium betonicum* L'Hér., its original description (L'Héritier 1788) included one illustration (number XL) and made reference to collections made by Banks and Solander (with Cook during his first circumnavigation voyage) and by Masson in Madeira. Furthermore L'Héritier (1788) also cited this taxon as a synonym of the pre-Linnean polynomial *Salvia major folio glauco serrato* that was published by Sloane (1707). There are four sheets at BM that have original material associated to the protologue of this species. The first one is housed in the Sloane Herbarium and has one specimen with three sterile fragments (BM000589591). This collection matches the description and illustration of Sloane's (1707) polynomial. We did not chose this specimen as a lectotype because we preferred to select an actual herbarium collection listed by L'Héritier (1788). The second relevant specimen is also part of the historical collections of BM and it has two small leaves of this species that were collected by Banks and Solander in Madeira. They are mounted on a sheet that has mixed collections of at least six species, three of which are from Brazil and were not identified. The remaining three (*Morella faya* (Aiton) Wilbur, Myricaceae; *Picconia excelsa* (Aiton) DC, Oleaceae, and *T. betonicifolium*) were collected in Madeira. This sheet corresponds to folio 8 of a set of herbarium specimens that are bounded in a book that bears the title of *Plants of Cook's First Voyage 1768-1771*. Because this specimen has only two small leaves it was not selected as the lectotype. The third sheet with original material is in the General Herbarium at BM (barcode numbers BM000829332 and BM001025250). Based on the label information (on the back of this sheet), the sheet comprises three collections of *T. betonicifolium*. One is from Banks and Solander, the second was collected by Masson and the third made by an unknown collector in Madeira in 1763. The sheet has a total of six fragments and two of them are sterile. From the labels it is not clear which of these fragments can be assigned to the three collections. Given these uncertainties regarding the provenance of material mounted on this sheet, we chose not to select any of the material as lectotype. The specimen we designated as the lectotype, also housed in the General Herbarium, was mounted on the fourth sheet (BM013825662). It has three sterile fragments of a single specimen collected by Banks and Solander in Madeira. There are two labels, one of which is printed and states that it is a collection made in Madeira by Banks and Solander in 1768. The second label is handwritten and refers to Sloane's (1707) polynomial ("*Salvia major folio glauco serrato* Sloane. Hist. [illeg.] 17. t. 3 f 2"). Since this specimen does not depict flower details we have designated as an epitype a specimen housed in ORT (1057) which was also selected as the epitype of *Teucrium betonicifolium* (see above). The name *T. betonicum* L'Hér. has been used in most floristic studies of Madeira to refer to this species (e.g., Vieira 1992; Press 1994; Jardim and Francisco 2000; Menezes de Sequeira *et al.* 2008, 2012). Our nomenclature treatment establishes that *T. betonicifolium* Jacq. is a valid and legitimate name that was published earlier than *T. betonicum* L'Hér. and is therefore the correct name for this Madeiran endemic.

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4. AUTHORS' CONTRIBUTION

Botanical history review: ASG, JFO, MCD, MMR
Nomenclature: JFO, KG
Location and taxonomic identification of relevant herbarium specimens: ASG, JFO, MAC, MCD, MMR
First draft: JFO, KG
Review and edition of the final draft: all authors.

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RICHARD THOMAS LOWE, AN UNKNOWN BOTANICAL ILLUSTRATOR

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Abstract

Illustration is undoubtedly part of botanical history. In the early 19th century, as botanical Latin yielded more accurate descriptions, the need for illustration in scientific publications decreased. Nevertheless, advances in printing processes boosted the production of illustrated botanical periodicals at accessible costs. Therefore, coloured depictions of plants never ceased to be part of botany at all levels. Richard Thomas Lowe (1802-1874) studied the flora of Madeira from 1826, when he first visited the island, to his death. He is well known as the author of Madeira's first comprehensive Flora, but his work as a botanical illustrator is poorly known. We analysed the graphic production related to his first major paper, published in 1831, along with written documents, which, altogether, support a more complete understanding of Rev. Lowe's botanical work in Madeira and his relevant activity as an illustrator. We believe that joint analysis of illustrations and correspondence show that Lowe himself made the drawings after which the plate of the orchid *Goodyera macrophylla* in this paper was prepared, whose authorship was, up to now, unknown.

Keywords: Botanical illustration, *Goodyera macrophylla*, Madeira, History of Botany

RICHARD THOMAS LOWE: UN ILUSTRADOR BOTÁNICO DESCONOCIDO

Resumen

La ilustración es indudablemente parte de la historia botánica. A comienzos del siglo xix, cuando el latín botánico posibilitó descripciones más exactas, la necesidad de ilustraciones científicas decreció. Por otra parte, el desarrollo de las técnicas de impresión permitió la producción de revistas botánicas ilustradas periódicas a costes accesibles. Por ello, las láminas de plantas nunca han dejado de ser parte de la botánica a todos los niveles. Richard Thomas Lowe (1802-1874) estudió la flora de Madeira desde 1826, cuando visitó la isla por primera vez, hasta su muerte. Es bien conocido por haber sido el autor de la primera flora comprehensiva de Madeira, pero su labor como ilustrador botánico es poco conocida. En este trabajo analizamos la producción gráfica de su primer trabajo importante, publicado en 1831, junto con documentos escritos que juntos permiten conocer la extraordinaria labor del reverendo Lowe como botánico en Madeira, incluyendo su relevante actividad como ilustrador. Creemos que el análisis conjunto de sus ilustraciones y de su correspondencia muestra que fue el propio Lowe realizó los dibujos que dieron lugar a las láminas de *Goodyera macrophylla* de este trabajo, que hasta ahora se consideraban de autor desconocido.

Palabras clave: ilustración botánica, *Goodyera macrophylla*, Madeira, Historia de la Botánica.

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1. INTRODUCTION

Botanical illustration plays its part in the history of botany. Complementing herbarium specimens, it was the only way, until the beginning of the 19th century, to register colour, physiognomy and other details less resistant to decay.

By the early 19th century, botanical Latin was largely developed and thoroughly precise, and thus the importance of illustration as a means to convey plant features in scientific publications decreased (Stern 1966). Nevertheless, the production of botanical illustration did not diminish, since some botanists still found it useful to produce detailed depictions of plants along with descriptions. This relation is discussed, for instance, by Felix Avelar Brotero (1744-1828) who, despite advocating the adequacy of words for accurately describing minute details in plants (1788), later recognized the advantages of combining detailed descriptions with good quality illustrations. His "Phytographia Lusitaniae" (1816; 1827) encompasses 181 splendid engravings (Castel-Branco 2004). Moreover, the, popularity of botany with the general public grew in that period. The quality of illustrations increased enormously, since living specimens were now commonly available in botanical gardens, and artists no longer had to rely on flat, dried herbarium specimens (Chansignaud 2016). Illustrated books became luxury items for wealthy collectors, and the production of expensive botany volumes, often hand-coloured, thrived (Chansignaud 2016). At the same time, the middle classes developed an interest in gardens and plants, and became avid consumers of less expensive publications with coloured botanical illustrations (Secord 2002). Advances in the production of paper and printing processes reduced publication costs and periodicals on botany and gardening multiplied (Chansignaud 2016; Burns 2017).

The utility of coloured representations in teaching natural history was a topic of public discussion in the 1830s (Secord 2002), but its value was acknowledged long before by botanists. Two noteworthy examples are those of William Jackson Hooker (1785-1865) and John Stevens Henslow (1796-1861). William Hooker, whilst professor of Botany in Glasgow University from 1820 to 1841, supplied his students with copies of his book "Botanical illustrations: being a series of figures designed to illustrate the terms employed in a course of lectures on botany, with descriptions", published in 1822 (Secord 2002). John Henslow was a professor at Cambridge, of mineralogy from 1822 and of botany from 1827. His lectures were

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extremely popular, in part due to the use of coloured illustrations and large diagrams, as stated by some of his most prominent pupils (Darwin 1877, July 6; Jenyns 1862).

Drawing was an important tool in botanical practice: for students, it was a tool for developing observational skills; in common practice, a way to record traits which do not fit in herbarium sheets, like cumbersome organs, plant habit and habitat; in expeditions to distant places, it was used to record particularly delicate or perishable features of specimens, like flower colour in orchids (Bleichmar 2006; Francisco-Ortega *et al.* 2015); and as part of the process of acquiring and producing knowledge, since the act of drawing requires the careful observation of the subject in order to select the fundamental aspects of the plants depicted, understanding in this procedure what are the distinguishing characters of the plant and how to synthesise such information (Secord 2002). We believe that Lowe's illustration practice is an example of the latter and that it was part of his methodology to approach the flora of Madeira in his early years.

Richard Thomas Lowe (1802-1874) was born in Derbyshire, England, and studied at Cambridge University, where he attended Henslow's lectures. Henslow used to take his students on botanical field trips, and Lowe probably developed his interest in botany at that time, learning from Henslow the importance of direct observation and the convenience of drawing for recording new findings (Jenyns 1862).

Lowe first visited Madeira in 1826 and spent a year on the island as Travelling Bachelor of the University of Cambridge (Peile 1913), staying afterwards as temporary chaplain and finally as chaplain of the English Church, from 1833 to 1852, regularly returning afterwards (Newell 1931). Lowe became interested in the local flora and fauna. Throughout his life, he assembled substantial natural history collections, including an impressive herbarium, and published more than 60 papers and books on the flora, fishes and terrestrial molluscs of the archipelagos of Madeira, Canaries and Cape Verde. Some of his earlier works were illustrated, and the authors responsible for the original drawings were usually identified, except for a magnificent lithography of a native Madeiran orchid (*Goodyera macrophylla*).

In this paper, we establish Lowe's authorship of the orchid's plate by analysing his correspondence, surviving sketches and drawings that may positively be attributed to him. Therefore, we aim to disclose a less known facet of this botanist, that of botanical illustrator. We also emphasise the importance of botanical illustration as a tool in the development of Lowe's pioneer work in studying *in loco* the flora of Madeira. The results presented here are part of a broader research on Lowe's work, in particular on the different forms of graphic production associated to his activity in natural history.

2. MATERIALS AND METHODS

An analysis of all 61 publications of Richard Thomas Lowe on natural history shows that 18 of these are illustrated: twelve on flora, five on fauna and one covering both subjects. These publications contain a total of 16 illustrations of plants, published from 1831 to 1835, mostly after original drawings and watercolours by his friends Rev. Miles Joseph Berkeley (1803-1889), Miss Mary Young (1790-1843), and the Hon. Miss Caroline Norton (1798-1875). Lowe himself signs three of the illustrations. However, one of the six illustrations in the paper "Primitiae Faunae et Florae Madera et Portus Sancti", published in 1831 in *Transactions of the Cambridge Philosophical Society* (volume 4, pages 1 to 70), a splendid folded plate, is not signed and its author is in no other way mentioned.

Illustrated publications, original drawings and Lowe's correspondence were analysed in an attempt to shed some light on the origin of the unsigned plate published in 1831. We made use of the collection of drawings and watercolours marked "Ex Bibl. R.T. Lowe" held by the Archives at the Royal Botanical Gardens, Kew (RBGK), and probably bought in the auction of Lowe's library at Sotheby's in 1875, although no original material is listed in the printed catalogue of the auction[1] (Sotheby, Wilkinson & Hodge 1875). Some of these drawings were signed "R.T.L." in Lowe's handwriting, others were signed by others, usually people close to Lowe, but most are unsigned.

William Jackson Hooker was a friend of Lowe's and his chief correspondent regarding botanical matters. Hooker was Professor of Botany in Glasgow University and, from 1841, Director of the RBGK (Brittain 2006). At least from 1827 onwards, Lowe and Hooker corresponded regularly, the letters received by Hooker kept in the Director's Correspondence collection at the RBGK and totalling 82.

Letters addressed to other correspondents and including useful information for this task were also retrieved: 3 letters addressed to Robert Brown (1773-1858) and kept at the British Library; 4 letters sent to Charles Darwin (1809-1882), available through the *Darwin Correspondence Project*[2]; 8 letters to Henslow from his early years in Madeira, kept at the Cambridge University Archives; 9 letters to Leonard Jenyns (1800-1893), kept at the Bath Royal Literary and Scientific Institution; and 7 letters sent to Philip Barker Webb (1793-1854), available through the *Proyecto Humboldt*[3]. Robert Brown was Keeper of the Botanical Collection at the British Museum, occupying a central position in European Botany in the mid-nineteenth century (Mabberley 2009). Darwin needs no introduction, and both Leonard Jenyns (later Blomefield) and Philip Barker Webb were friends of Lowe's. The first was an accomplished naturalist, one of the founding members of the Zoological Society of London, and the latter was a wealthy traveller and botanist who studied the natural history of the Canary Islands.

[1] There is no definite evidence on this. It is a supposition, proposed by the Illustrations Team at Kew Archives, with which we agree.

[2] Available at http://www.darwinproject.ac.uk.

[3] Available at http://humboldt.fundacionorotava.es.

3. RESULTS

Lowe's first major publication about Madeira–"Primitiae Faunae et Florae Madera et Portus Sancti" (Lowe 1831)–is a long paper, read at a Cambridge Philosophical Society's meeting on the 15th November 1830, in which he describes 67 species of plants, most of them proposed as new to science, and 71 species of molluscs. Lowe talks about his plans concerning this publication in two letters written on April 23rd, to his friends Leonard Jenyns and Robert Brown:

> I am looking out every day for a Vessel to convey my mother and myself to England; and I shall try to get down to Cambridge as soon as possible after landing. [...] My intention now is, to throw off this summer a sort of *Prodromus Prodromi*: in the shape of a pamphlet, merely containing the specs. chars. of my new land Mollusca and plants [...] I shall be anxious to hear how you like my plan; of w[hi]ch however I can now (when we meet) give you a better analysis than it contains. (Lowe 1830a, April 23).

> I am also thinking of getting out my new species of plants in a brief form during the course of the present Summer, as a precursor to a more general work. [...] I hope to obtain yr. opinion on these & some other points, I have particularly an Orchideous plant & a Fern w[hi]ch I reserve, to have the pleasure of communicating with you personally about them. The former I hope to prove a new Genus. (Lowe 1830b, April 23).

His enthusiasm for the new orchid species had already been discussed with a closer friend, Philip Barker Webb, an English botanist then living in the Canary Islands. In a letter sent in November 1829, Lowe tells Webb about the time spent in the North part of Madeira Island during September and October that year and of the results of his explorations, mentioning the orchid for the first time, as well as the drawings he made of this plant:

> I added about 30 Phaenog. plants to the Flora while I was at Sta. Anna. One a lovely Orchideous plant I think a new genus allied to Neottia (if not Ponthieva R.Br.). I have only been able to get one specimen in flower. The spike I have preserved in spirits & made accurate drawings of the whole plant. (Lowe 1829, November 12).

Back in England in the summer of 1830, Lowe prepared the publication and the illustrations and engravings required, as he describes to Professor Henslow and, a few days later, to his friend W.J. Hooker:

> Sowerby[4] is hard at work (I hope) with my shells, making the requisite figures, for w[hi]ch he is to have 3 s. a piece. About 50 figs. I believe will be requisite, – that is to be done by him, for I shall furnish some myself. [...] I have chosen a man

[4] George Brettingham Sowerby (1812-1884), naturalist, illustrator and conchologist.

named Zeiter[5] to engrave them. To my judgment he is the best [...] in London. [...] Engelman[6] has got my new Goodyera (macrophylla) to littograph. A *plain* plate will answer every purpose & is to cost (engraving) 2 £ I have contrived that the plant shall be packed into a single folded (not double) plate. (Lowe 1830, August 22).

I left with Mr. Hunneman[7] for you a box of plants of Goodyera which proves new and which I have called Goodyera macrophylla. I only found it last autumn, and after carrying the plant twice across the island, had at last the satisfaction to see it flower. I brought drawings of it with me which were intended for should be underlined, but they have beholded so handsomely to me at Cambridge about the plates for my intended paper in the Philosophical Society Transactions that I am now having them lithographed by Engelmann for myself to accompany the paper. I hope your plants will do well, for it is excessively rare. (Lowe 1830, August 31).

However, due to problems with the illustrations of land shells, the publication was delayed, as Lowe explains to Hooker:

I am very busy now getting my shells engraved &c - & my paper is with the printer though owing to an unfortunate mistake of mine in leaving some shells behind in Madª w[hi]ch must be fig[ure]d I fear it cannot be regularly publ[ishe]d before Spring. (Lowe 1830, October 26).

Finally, in 1831–in June, according to a handwritten note of undetermined authorship in the copy held by the Library and Archives at the Natural History Museum, London–the paper was published in the part I of volume 4 of the "Transactions of the Cambridge Philosophical Society", with 6 plates[8], all engraved by Engelmann, Graf, Coindet & Co.: *Goodyera macrophylla*, unsigned (presented in figure 1), a folded plate depicting the whole plant in natural size and eleven details of the flower; *Tolpis crinita* and *Ononis dentata*, signed by Miles Joseph Berkeley; *Sedum fusiforme*, signed "R.T.L."; and two plates with illustrations of 26 and 40 shells, both signed by George Brettingham Sowerby Jr.

The original watercoloured drawing of *Sedum fusiforme*, signed by Lowe himself, together with a proof of the plate, is held at Kew Archives, marked "Ex Bibl. R.T. Lowe", as is the original watercolour of *Tolpis crinita* and a proof of the published illustration.

The collection of drawings held at Kew includes two watercolours of *Goodyera macrophylla*, both signed by Richard Thomas Lowe (presented in figures 2 and 3). The first drawing, of the whole plant, although with the inflorescence cut

[5] John Christian Zeitter (1797-1862).

[6] Engelmann, Graf, Coindet & Co., the London branch of Franco-German Godefroy Engelmann's lithographic printing business, opened in 1826 and closed in 1830.

[7] John Hunneman (fl. 1820-1839), a London bookseller and agent specialized in botany.

[8] This article was fully reprinted in 1833; and again in 1851, without the plant plates and corresponding explanatory notes (Stafleu & Cowan 1831).

Figure 1. *Goodyera macrophylla* Lowe. Tab. I. Lowe, RT. 1831. Primitiæ faunæ et floræ Maderæ et Portus Sancti sive, Species quædam novæ vel hactenus minus rite cognitæ animalium et plantarum in his insulis degentium breviter descriptæ. Transactions of the Cambridge Philosophical Society 4: 1-70; pl. 1-6. © Copyright The Board of Trustees of the Royal Botanic Gardens, Kew.

Figure 2. *Goodyera macrophylla* Lowe. Watercoloured drawing by Richard Thomas Lowe. © Copyright The Board of Trustees of the Royal Botanic Gardens, Kew.

Figure 3. *Goodyera macrophylla* Lowe, flower details. Watercoloured drawing by Richard Thomas Lowe. © Copyright The Board of Trustees of the Royal Botanic Gardens, Kew.

and presented separately, includes nine separate depictions of details of the flower, five of them numbered one to four; it is signed in the bottom right corner "R.T.L. delt." in Lowe's handwriting. The second drawing depicts the whole flower and 12 details, numbered one to eleven in ink and then corrected to two to twelve in pencil; it is signed and dated "R.T.L. Sta. Anna, Sept. 1829", again in Lowe's handwriting, and includes, also in pencil, the plant name and explanatory notes for the details.

4. DISCUSSION

Comparing the *Goodyera macrophylla* illustration published in 1831 with the two watercoloured paintings signed "R.T.L." in the "Ex Bibl. R.T. Lowe" collection at RBGK, and taking into account the excerpts of Lowe's letters, it is safe to say there is a clear link between them. All details depicted in the published illustration were directly engraved after Lowe´s watercolour, since they are exact copies of these details. Moreover, the numbering of figures in the plate matches the corrected numbering of the details in the original watercolour presented in figure 3, from 2 to 12.

The whole plant, however, does not exactly match Lowe's drawing. It may have been lithographed after a different drawing or after a living plant. However, if the plant had been lithographed from another original drawing by Lowe, the author would have been identified, as were the authors of the other plates in his paper. Considering that Lowe told Hooker he had "left with Mr. Hunneman for you a box of plants of Goodyera [...]. I brought drawings of it with me which were intended for you, but [...] I am now having them lithographed", it is safe to assume that Engleman did not have a flowering plant to draw from. Lowe carried from Madeira to England both plants and drawings intended for his friend Hooker, but he only delivered the plants, since the drawings were kept to be lithographed by Engleman. Plausibly, Lowe's drawing may eventually have served as inspiration, being freely transcribed into lithography by the engraver, who took some liberty in his etching. There are several resemblances linking the two images: the positioning of the plant in the plate is similar, with the inflorescence scape "broken" so that the plant fits the page in natural size; the general form of the creeping rhizome and the base of the flowering stem is quite the same, although mirrored; six leaves are represented in both images, with the lower one bending behind the rhizome. Moreover, the slightly wavy stem represented in the published plate, although very elegant, does not correspond to the actual plant, which is perfectly straight, as represented in the original watercolour (see figure 4). The fact that the published illustration is not a precise copy of the watercolour is, undoubtedly, why the author of the original drawing is not identified. Adaptation of the original drawings to fit the requirements of the editor was not uncommon, at the time.

The resulting publication was certainly appreciated by Lowe's fellow naturalists, since it was reprinted twice. Professor Henslow thought it worth sending to his pupil Charles Darwin (1809-1882), who was about to embark aboard HMS Beagle, on his way to the Southern Hemisphere:

Figure 4. *Goodyera macrophylla* Lowe in its habitat.
Photo by Miguel Menezes de Sequeira.

As I have received the plates to Lowe's paper, I thought it w[oul]d be a pity not to forward them to you, & so shall entrust them to L. Jenyns who goes to Town tomorrow to send by some Plymouth Coach–They may be of service in directing your attention whilst collecting land shells (Henslow 1831, November 20).

In the time span 1829-1833, Lowe showed an active interest in improving his drawing technique and talked about publishing plans. In 1832, he wrote to W.J. Hooker:

I have no brush thicker than a knitting needle nor any proper colors for greens. If you would give me a little instruction in coloring you see how useful it would be, and if I could acquire tolerable rapidity I could send you abundance of useful drawings. I find no difficulty at all in sketching; coloring is the business. (Lowe 1832, May 18).

And subsequently:

Your remarks for my drawings make me just proud –not of the drawings but of your kindness in giving me such encouragement. If you can spare me some time or other any of your own castaways, I shall then perhaps learn how to remedy some of their defects. I have no idea for instance how to give any Shades to a flower of great depth and intensity of coloring except by imparting so much dullness to the whole as to be intolerable in contrast with the vividness of nature. Greatest freedom I suppose may come in time. (Lowe 1832, December 5).

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 59-71

No sketches of Lowe were found dated later than 1833. This year he became chaplain in Madeira, getting more involved in clerical duties, temporarily laying botany aside. At that time, he became quite enthusiastic about the work of Mary Young and Caroline Norton, accomplished artists who, for some time, illustrated his works. In a letter to W.J. Hooker (Lowe 1833, August 22), he even asks for the price of octavo and quarto plate engraving and colouring, for "a scheme for publishing in N^{os} 'Illustrations of the Mad^{a}. Fl^{a}.'–quite in embryo as yet". However, this project was never carried out, and Lowe's interest in botanical illustration seemed to have vanished in the early 1840s, when he controversially became involved in Anglo-Catholicism, the so-called 'Oxford Movement', which would take him back to England.

These are the first results of a broader research concerning the work of Richard Thomas Lowe. Illustration was a significant tool in Lowe's exploratory work of Madeira's native flora, at least during the first decade he spent on the island. Drawing may have been part of his process of botanical discovery, and in the development of the observation and analytical skills required for deriving distinguishing characters in specimens of potential new species.

It is clear that, during those early years, Lowe made an effort to illustrate new species and that he made plans to produce an illustrated Flora of the archipelago. Results from this effort can be found in the illustrations marked "Ex Bibl. R.T. Lowe" in the Archives at the RGBK, mostly unpublished. These plans were later abandoned, since Lowe's *Manual flora of Madeira*–to this day a major reference work for the Botany of Madeira–is not illustrated.

Nevertheless, Lowe's approach to the research of Madeira's native flora was pioneer in its systematic character and because he studied plants in their natural habitat. In the 1820's, when Lowe arrived in Madeira, it was not an unexplored territory and many of its native plants were already known and commonly cultivated in European gardens, thanks to the work of several plant collectors. Therefore, the abundance of new species he found came as a surprise and Lowe may have felt overwhelmed by the dimension of the task in front of him, as he told Henslow (Lowe 1829, May 6): "I have been working without intermission all winter at my Fauna and Flora, but matter grows so on my hands God knows when I shall get through with it. Fresh plants turn up every day and often new ones." Lowe's botanical work in Madeira resulted in more than 200 plant species new to science.

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6. AUTHORS CONTRIBUTION

Conceptualization: all authors.
Methodology and data gathering: SM.
Data analysis: SM.
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Review and edition of the final draft: all authors.

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SIR JOSEPH HOOKER ON *INSULAR FLORAS*: HUMAN IMPACT AND THE NATURAL LABORATORY PARADIGM

Mark Carine* & Miguel Menezes de Sequeira**

Abstract

In 1866, the botanist Joseph Dalton Hooker (1817-1911) delivered a lecture to the British Association for the Advancement of Science in Nottingham, U.K. entitled *Insular floras*. The lecture has been described as "the first systematic statement of the importance of islands for evolutionary studies". As such, it can be seen to have contributed to the development of the "natural laboratory paradigm" that views islands as model systems for studying ecology and evolution. Hooker's lecture also highlighted another key driver in shaping island diversity patterns, namely human impact. How and when does human impact compromise the utility of islands as 'natural laboratories' for studying evolution? To date, no fewer than eight "shortfalls" –knowledge gaps that impact on studies of biodiversity– have been described. In this paper, we suggest that a further shortfall is in order –a Hookerian shortfall– to account for uncertainty in the extent to which biodiversity patterns reflect natural rather than anthropogenic processes. The potential for natural history collections to help address this shortfall is discussed.

Keywords: Island biogeography, evolution, human impact, herbarium.

LA CONFERENCIA *INSULAR FLORAS*, DE SIR JOSEPH HOOKER: EL IMPACTO HUMANO Y EL PARADIGMA DEL LABORATORIO NATURAL

Resumen

En 1866 el botánico Joseph Dalton Hooker (1817-1911) impartió una conferencia a la Sociedad Británica para el Avance de la Ciencia en Nottingham, titulada *Floras insulares*. Esta conferencia ha sido catalogada como «la primera declaración sistemática de la importancia de las islas para estudios evolutivos». Como tal, puede decirse que contribuyó al desarrollo del concepto de las islas como «paradigma de laboratorio natural», que contempla estas como modelos sistémicos para el estudio de ecología y evolución. La conferencia de Hooker también subrayó la existencia de otro elemento clave en la configuración del patrón de la biodiversidad insular, concretamente, el impacto humano. Cuándo y cómo puede el impacto humano comprometer su utilidad como «laboratorio natural». Hasta el momento se han postulado no menos de ocho carencias, o faltas de conocimiento, que impactan los estudios de biodiversidad. En este trabajo proponemos una nueva carencia, la hookeriana, para considerar la incertidumbre de que los patrones de biodiversidad observados respondan más procesos naturales que impactos antrópicos.

Palabras clave*:* biogeografía insular, evolución, impacto humano, herbario.

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Figure 1. A photograph of Sir Joseph Dalton Hooker (1817-1911), taken in 1868, two years after his *Insular Floras* lecture. © The Trustees of the Natural History Museum, London.

1. INTRODUCTION

On August 27th, 1866, Joseph Dalton Hooker (1817-1911; Figure 1), then Director of the Royal Botanic Gardens, Kew in London, U.K., delivered a lecture to the British Association for the Advancement of Science in Nottingham, U.K. His *Lecture on Insular Floras* (hereafter *Insular Floras*) was given to an estimated audience of 2000 people (Berry, 2009). The text of the lecture was subsequently published in parts in the *Gardeners Chronicle* and later in its entirety as a pamphlet (Hooker, 1896, Figure 2). It was reprinted with a commentary by Williamson (1984). Berry (2009), in reviewing Hooker's contribution to island biology, considered the 1866 *Insular Floras* lecture to be particularly significant describing it as a '...*landmark in*

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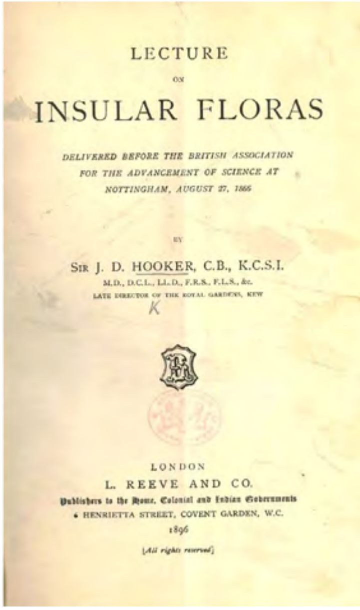

LECTURE

ON

INSULAR FLORAS

DELIVERED BEFORE THE BRITISH ASSOCIATION
FOR THE ADVANCEMENT OF SCIENCE AT
NOTTINGHAM, AUGUST 27, 1866

BY

SIR J. D. HOOKER, C.B., K.C.S.I.
M.D., D.C.L., LL.D., F.R.S., F.L.S., &c.
LATE DIRECTOR OF THE ROYAL GARDENS, KEW

LONDON
L. REEVE AND CO.
Publishers to the Home, Colonial and Indian Governments
6 HENRIETTA STREET, COVENT GARDEN, W.C.
1896

[All rights reserved]

Figure 2. Title page of Hooker's *Lecture on Insular Floras*, published in its entirety as a 36 page booklet by L. Reeve & Co. © The Trustees of the Natural History Museum, London.

scientific support for the Origin... [i.e Darwin, 1859]' and '...*the first systematic statement of the importance of islands for evolutionary studies.'*

Hooker's lecture addressed the relationships and evolution of island floras and also considered the extent of human impact on islands and its significance. In this paper we give an overview of Hooker's lecture before considering how these two aspects of island floras he discussed –their role as 'natural laboratories' for studying evolution on the one hand and their highly disturbed condition on the other– can be reconciled.

1.1. Hooker and islands

Hooker was an influential figure in 19th century botany. By the time he delivered his *Insular Floras* lecture he had succeeded his father William Jackson Hooker as the second Director of the Royal Botanic Gardens, Kew, a post he held for 20 years. He served as President of the Royal Society of London, the United Kingdom's premier scientific academy, from 1873 to 1878. He received a knighthood for his work in India and was made a member of the Order of Merit, an award in the personal gift of the British sovereign. Hooker maintained an extensive and international network of correspondents (Endersby, 2008a; see also http://jdhooker.kew.org/p/jdh) and his botanical interests were wide ranging. Eminent in both palaeo- and neobotany, Hooker was a prolific collector and explorer and the author and editor of monumental taxonomic works including the seven-volume *Flora of British India* (Hooker, 1872-1897) and *Genera Plantarum* (Bentham & Hooker, 1862-1883). He was also an advocate of the evolutionary theory developed by his friend Charles Darwin. Hooker considered himself to be a 'philosophical botanist' and was concerned not only with documenting patterns of diversity but also explaining them (Endersby, 2008a & b).

Hooker's *Insular Floras* lecture reflected his particular interest and wide experience of oceanic island floras. As a young Assistant Surgeon in the British Royal Navy, Hooker served on HMS *Erebus* under James Clarke Ross on the 1839-1843 Antarctic expedition to the magnetic South Pole. The voyage took Hooker to islands in Macaronesia (Madeira, Tenerife in the Canary Islands and Santiago in the Cape Verdes), the South Atlantic (the São Pedro and São Paulo rocks, Trindade, Ascension, Saint Helena, the Falkland Islands) and the sub-Antarctic and Antarctic (Auckland, Crozet, Kerguelen, Cockburn and Campbell islands). He used the opportunity to collect extensively; everything from algae to seed plants. In writing up the botanical outcomes of the *Erebus* voyage, Hooker produced Floras of New Zealand, the Antarctic islands and Tasmania (Hooker, 1844-1860) but his interests in island floras extended beyond those he had visited on the voyage; his *Enumeration of the Plants of the Galapagos Archipelago* (Hooker, 1847) for example, was made at the invitation of Charles Darwin and was based on Darwin's collections from the archipelago. It was a project that established a life long friendship between the two men.

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 73-88

1.2. Explaining insular floras

Hooker's *Insular floras* lecture provided an outline of the physical characteristics and floras of seven oceanic islands or island groups. He discussed the Macaronesian archipelagos of the Azores, Madeira, Canary Islands and the Cape Verdes, the south Atlantic islands of Ascension and St Helena and the sub-Antarctic Kerguelen Islands. Hooker had botanized on all except Azores but his interest in the archipelago is evident from surviving correspondence between, for example, Hooker and Darwin (https://www.darwinproject.ac.uk/).

Hooker went on to distinguish two types of relationship of these insular floras: those of affinity and those of analogy. He highlighted analogous similarities in insular floras '*due to physical conditions common to them all –to their climate, exposure, limited area and distance from continents, etc...*' noting, for example, the distinctive growth form spectrum of island floras and the phenomenon of insular woodiness, writing that '*Plants which are herbs on continents, often either themselves become shrubby on islets, or are represented by allied species that are shrubby or arboreous*'.

His 'relationships of affinity' concerned the biogeographic relationships of insular floras. He noted '*in all cases the flora is quite manifestly closely allied to some* *one continental Flora, and that however distant it may be from the mother continent, and however it by so much approximates to another continent, it never presents more than faint traces of the vegetation of such other continent',* a pattern reflected in contemporary phylogenetic analyses of oceanic island seed plant floras (e.g. Carine et al., 2004).

Writing on the Azores in this context, an archipelago located 1700 km from Europe and 2400 km from America but with prevailing winds from the West, Hooker noted '*The only trace of American influence on the Azorean Flora that I can substantiate, is in a species of the Umbelliferous genus* Sanicula'. Recent phylogenetic work has confirmed the largely European affinity of the endemic seed plant flora and indeed suggests that *Sanicula azorica* is in fact European in its affinities (H. Schaefer, TUM, pers. comm.). Endemic taxa with American sister taxa are represented, for example in *Lactuca* (Dias et al., 2018) and *Solidago* (Schaefer, 2015), but they are few in number and Hooker's observations on the flowering plant flora still stand (although the situation is more complex in the cryptogams; see Vanderpoorten et al., 2007).

Hooker reflected on the impact of what would today be considered to be the island life cycle (Whittaker et al., 2007) on levels of diversity. Discussing in particular 'old species', he noted *'I believe that a principal cause of the rarity or extinction of old species on oceanic islands is the subsidence they have all experienced. This sinking of the island operates in various ways. 1. It reduces the number of spots suitable to the habits of the plant. 2. It accelerates that struggle for existence which must terminate in the more hardy or more prolific displacing the less hardy or less prolific...'*

He concluded his essay with a discussion of hypotheses to account for the 'stocking of an oceanic island with plants from the continent'. He discussed both dispersal and land bridge hypotheses and carefully assessed the evidence in support of each. Whilst land bridges are no longer considered a plausible hypothesis to explain the origins of oceanic island floras such as those of Macaronesia, it is nevertheless evident in the case of the Macaronesian islands that their 'stocking' has been complex and that their floras contain both neo-endemics, resulting from (relatively) recent dispersal and also palaeoendemics that are the result of continental extinction processes (e.g. Mairal et al., 2015).

Many of the questions that Hooker addressed in his lecture remain central to island biogeographic and evolutionary studies today. His lecture played an important role in highlighting the value of islands as 'natural laboratories'; systems ideally suited for in-situ studies of evolution (Whittaker and Fernández-Palacios, 2007) and it is clear that islands continue to play a major role in the development of key concepts in biology (Warren et al., 2015; Santos et al., 2016; Patiño et al., 2017, Whittaker et al., 2017).

1.3. Hooker on human impact

Hooker's lecture was not restricted to a presentation of island biogeography and evolution. He also addressed the impact of humans on island floras.

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 73-88

Figure 3. The type specimen of *Trochetiopsis melanoxylon* collected by Joseph Banks and Daniel Solander on St Helena in 1771. The species is endemic to St Helena. It is globally extinct and the Banks and Solander type collection made in 1771 was the last collection of the species. There are two other species of *Trochetiopsis* endemic to St Helena: *T. erythroxylon* is Extinct in the Wild and *T. ebenus* is Critically Endangered. Image from the Natural History Museum, London data portal (data.nhm.ac.uk), , used under a CC-BY 4.0 licence. © The Trustees of the Natural History Museum, London.

Writing on St Helena in the south Atlantic he commented that *'Probably 100 St Helena plants have thus disappeared from the Systema Naturae since the first introduction of goats on the island.'* St Helena was uninhabited before the sixteenth century. Goats were introduced as a source of meat in the early 1500s and, as a result of its strategically important location, the island was colonised and became a major port of call for the British East India Company from the mid-1600s onwards. The introduction of large herbivores and invasive plant species and the harvesting of forests for timber brought about rapid and catastrophic changes to the native vegetation following the discovery and colonisation of the island (Cronk, 2000). Hooker's estimate of the scale of species extinction may be an over-estimate but the St Helena flora has, undoubtedly, been hugely impacted by humans. Today, it is among the most threatened in the world with one quarter of the 35 recognised endemic flowering plant species considered globally extinct or extinct in the wild (Figure 3). The most recent extinction was of *Nesiota elliptica* Roxb. When Joseph Banks and Daniel Solander visited the island in 1771 during James Cook's first circumnavigation, there were trees up to 9 m high; a century later only 12-15 trees remained, all much shorter in stature. The last wild plant died in 1994 but seedlings and a cutting propagated from this individual survived until the last succumbed to fungal infections in 2003 (Lambdon and Ellick, 2016). Cronk (2016) used the *Nesiota* example to illustrate the sometimes long period of time taken for extinction to occur following an extinction-causing event and to highlight the need to focus on estimating extinction debt (see also, for example, Triantis et al., 2010, Otto et al., 2017 in the context of Macaronesia) rather than census extinction if we are to understand the true scale of biodiversity loss.

Hooker also drew attention to the impact of humans on the Madeiran flora. He commented *'But in Madeira the agency of man must not be overlooked. The natural history of that lovely island has undergone such a revolution within the last 400 years, as under the ordinary operations of Nature can only be measured by the Geological Chronometer'.*

This statement is at odds with the idea that the extensive areas of Madeiran laurisilva are largely primary forest (e.g. http://whc.unesco.org/en/list/934) but it is certainly consistent with historical data. Early descriptions of Madeira (and also the Azores) refer to large forests comprising some species still present in the region but others that are unknown and are probably extinct (Frutuoso, 1998; Dias, 2007). Early reports also document the rapid destruction of forest ecosystems in the fifteenth (e.g. Fernandes, 1940) and sixteenth centuries (Gaspar Frutuoso; see Frutuoso, 1998). Moore (2009, 2010) estimated that the development of massive sugar cane plantations and forest cutting for fuel to produce sugar from the 15th century onwards resulted in close to 16,000 ha of forest being cut by 1509; a less optimistic estimate would put that figure close to 25,000 ha. That corresponds to between one quarter and 40% of the total area of laurisilva destroyed by the early 16th century.

Evidence for the lack of forest or for a landscape converted to agriculture can also be found in the writings of 17th and 18th century authors such as Hans Sloane (Menezes de Sequeira et al., 2010). Later, the influence of Alexander von Humboldt led authors such as Bowdish (1825), Khul (1826) and Lowe (1857) to propose vegetation belts for Madeira that were largely based on the distribution of cultivated plants and landscapes intensively used for grazing. Nineteenth century images (Pupo-Correia et al., 2010) reveal a barren landscape largely used for agriculture and heavily grazed where tall trees could seldom be found and, where they did occur, they were usually linked to villages or houses (Figure 4).

Recent research has revealed that even the oldest forest stands in Madeira show signs of historical harvesting dating back to about 150 years ago (Patiño et al., 2018). The recovery of the laurisilva in Madeira was therefore a late and recent process that took place mostly in the 20th century. Madeiran laurisilva today is thus likely to be much more extensive than it was in the relatively recent past. Hooker's view of the laurisilva during his visit aboard the *Erebus* would have been very different to that of a visitor today and inferences regarding its composition and evolution that would have been made in the early 1800s may have been very different to those made today if the history of the forests is not taken into account.

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 73-88

Figure 4. Repeat photography of Madeiran landscapes reveals the different fates of native vegetation through time. (a) and (b): Ribeira da Janela Valley. (a) Photograph taken by unknown photographer in the early twenty century showing large areas without vegetation cover forming clearings in a complex mosaic of forest and scrub. (b) Photograph taken in 2007 showing recovery of native vegetation in areas that were not covered in (a). The transition is to high-scrub or young forest with early secondary, shade intolerant species such as *Myrica faya* and *Clethra arborea*. (c) and (d): Old Curral dos Romeiros or Curral pequeno. (c) Photograph taken by unknown photographer between 1876 and 1878 showing the lack of native forest; some native vegetation, mainly heather (*Erica platycodon* subsp. *maderincola*), is scattered in the landscape particularly in less accessible areas. The trees are exotic species (e.g. Sycamore (*Piatanus* x *hispanica*) and pine (*Pinus pinaster*)). (d). Photograph taken in 2011 showing the increase of tree cover. However, unlike in (b), it is exclusively by exotic trees: Tasmanian Blue Gum (*Eucalyptus globulus*), Black wattle (*Acacia mearnsii*) and Sweet Pittosporum (*Pittosporum undulatum*). Images courtesy of Aida Pupo-Correia.

As the examples of St Helena and Madeira serve to highlight, humans have had a profound impact on island floras. Humans have brought about a major loss of island biodiversity but the effects of human activity on island plants is complex. Pressures change through time and the vegetation responds to those changes. Consequently, what is natural and what is human-mediated may actually be extremely difficult to separate.

1.4. Human impact and the natural laboratory paradigm

Hooker reflected on the significance of human impact for understanding island floras. In the context of St Helena he commented that '*Every one of those* [extinct species] *was a link in the chain of created beings, which contained within itself evidence of the affinities of other species, both living and extinct, but which evidence is irrecoverably lost.*'

Contemporary evolutionary and biogeographic analyses on islands range from broad-scale macro-evolutionary or biogeographic analyses to fine-scale analyses of speciation processes and next Generation Sequencing (NGS) approaches have the potential to greatly extend the scope of island evolutionary studies to encompass fundamental questions relating to the genetic basis of island diversification events. The acquisition of DNA sequence data at the genomic level at an ever-increasing rate, and for non-model organisms, is providing unprecedented opportunities to uncover the history of lineages (Sousa & Hey 2013; Ellegren 2014). It is not only allowing evolutionary relationships to be elucidated in rapidly evolving island lineages that were previously intractable (e.g. Mort et al., 2015) but is also allowing the genomic basis of speciation events to be investigated, to determine the number of loci involved in speciation, the nature of the genetic differences, and what those loci control (e.g. Almén et al., 2016; Paun et al., 2015).

But are there limits to our evolutionary inferences in oceanic island systems? Whilst islands have played a significant role as model systems in the development of evolutionary and biogeographic theory, such studies generally assume that the patterns of diversity that they document and that they seek to explain are the result of natural processes with the impact of humans not significant for the interpretation of those patterns. Given the breadth of human impact on islands, is this a reasonable assumption across the entire spectrum of evolutionary questions?

Jardim & Menezes de Sequeira (2008) and Menezes de Sequeira et al. (2013) have proposed that forest persistence in Madeira post-human colonization may be linked to the orographic complexity of the island. There is no evidence of any pristine forest in Madeira, but orographic complexity may have prevented the simultaneous disappearance of all forest patches. Conceivably, a dynamic mosaic of mature, although not pristine, forest survived in small and inaccessible areas, resulting in a higher level of conservation in Madeira than in the Azores, as has been observed for arthropods (Boeiro et al. 2018). However, this history certainly challenges the use of contemporary diversity patterns to make biogeographical comparisons between archipelagos. Helmus et al. (2014) demonstrated how human introductions have modified species diversity patterns in Caribbean *Anolis* lizards whilst Bochaton et al. (2017) showed how human-mediated extinction in *Anolis ferreus* in Guadeloupe has brought about a marked reduction in its morphological diversity. Seerholm et al. (2018) have drawn attention to the significant loss of genetic diversity in the kakapo on New Zealand as a result of European and pre-European human impact. These examples highlight how past human impact on islands has shaped the diversity patterns observed today on islands across evolutionary scales and how it may impact our interpretation of those patterns. As Whittaker and Fernández-Palacios (2007) noted, without understanding the impact of extinction, there is a danger of misinterpreting evolutionary patterns that are just the more resistant fragments of formerly rather different tapestries.

What is not clear is whether, as the focus of studies moves from broad-scale (e.g. the biogeographic relationships of island biota) to finer-scale questions (e.g. speciation genomics), anthropogenic rather than natural processes become increasingly significant in explaining the patterns we observe. Is there a critical point below which anthropogenic effects are so significant that robust inferences concerning natural, ecological and evolutionary processes are simply not possible? Is there a limit to the use of islands as 'natural laboratories' for studying evolution?

1.5. A hookerian shortfall?

Shortfalls in our knowledge of the diversity of island floras have been discussed by a number of authors. For example, Schaefer et al. (2011) discussed the significance of a Linnean shortfall (Brown and Lomolino, 1998) –the incomplete knowledge of taxonomic diversity– in understanding and explaining patterns of diversity in the flora of the Azores. The Linnean shortfall, together with the Wallacean shortfall (Lomolino, 2004) –the incomplete knowledge of taxon distributions– were first proposed in the context of conservation biology.

Further shortfalls in biodiversity knowledge have now been identified. Cardoso et al. (2011) proposed a Prestonian shortfall to account for the deficiency in knowledge of species abundance and population dynamics whilst Diniz-Filho (2013) proposed a Darwinian shortfall to account for lack of knowledge of the tree of life. Hortal et al. (2015) further extended the concept of shortfalls and proposed in addition three further shortfalls: the Raunkierian (lack of knowledge of species traits and their functions), Hutchinsonian (lack of knowledge about the responses and tolerances of species to abiotic conditions) and the Eltonian (lack of knowledge of species interactions and their effects on survival and fitness). Ficetola et al. (2018) recently proposed the Racovitzan impediment for our lack of knowledge of the biodiversity of unexplored environments.

Conspicuous by its absence from this list is the shortfall discussed here –the shortfall in our knowledge of the extent to which patterns of biodiversity are shaped by anthropogenic rather than natural processes– a shortfall that might be termed the 'Hookerian shortfall'. As is clear from his *Insular floras* lecture, Hooker was aware of this problem and he was, arguably, the first to articulate it.

In the context of island conservation, Nogue et al. (2017) have highlighted the importance of palaeoecological studies in establishing baselines. Paleoecological baselines could help to inform island evolutionary studies and address the 'Hookerian shortfall'. Historical accounts that bear direct testimony of human impact written by those who were witnesses to it may also be informative although they are often limited by poor taxonomic resolution.

Herbarium collections provide another source of data to help understand the 'Hookerian shortfall'. The world's herbaria contain an estimated 350 million botanical specimens (Thiers, 2016) collected over more than four hundred years. NGS techniques have not only greatly extended the potential scope of island evolutionary studies to encompass fundamental questions relating to the genetic basis of island diversification events but they have also expanded the range of material that may be used in studies of island biodiversity to include for example, archival herbarium specimens or wood samples that were difficult or impossible to utilise with traditional Sanger sequencing due to the degraded nature of the DNA they contain. Bieker and Martin (2018) recently reviewed the increasing use of archival plant samples in evolutionary and population genetic studies and to examine change over decadal or centennial time scales. For example, Mende and Hundsdoerfer (2013) used museum specimens to demonstrate in a continental setting, how novel patterns of molecular diversity can establish surprisingly quickly. Such changes are unlikely to be tractable using palaeoecological or, indeed historical textual analyses but may be tractable using archival samples.

Herbarium specimens are thus a potential source of data to test the robustness of diversity patterns and the processes inferred from those patterns through the last 400 years –a period of profound anthropogenic change– and the Atlantic islands may be particularly amenable to this since their strategic importance for European powers means that there has been a long history of collecting.

In the case of St Helena, for example, its flora was studied, documented and collected soon after colonisation. The oldest surviving collections were made by Stonestreet in 1698 and are at the Natural History Museum in London (Dandy, 1958); 60% of the known endemic plant taxa were collected before the 19th century and there is a rich historical record of the flora in herbaria. These early collections provide a record of the endemic flora of an oceanic island soon after its colonisation and a unique resource for understanding the profound changes in the island's flora brought about by human activity. To date, early collections from the island have provided evidence for large-scale range reduction in dominant tree species (Cronk, 1986) and have provided evidence for the scale and pace of extinction in the angiosperm flora (Cronk, 2000). Herbarium specimens from St Helena could be used to investigate how the loss of diversity within endemic species or lineages such as *Trochetiopsis* (Figure 3) impact on our inferences regarding the evolution of the flora.

Herbarium collections are a far from perfect sample of diversity as they are heavily biased in both space and time. However, they do provide a source of data on the species or lineages or genotypes or genes (depending on the evolutionary scale being addressed) present at a particular place at a particular time. In so doing, they provide a source of data that can be used to help test the robustness of biodiversity patterns through time and help to establish the significance of the Hookerian shortfall in island biogeography.

2. CONCLUSIONS

Hooker's lecture on *Insular floras* reflected his profound interest in the plant diversity of oceanic islands. It was rooted in his first hand experience of island floras gained through his time as an Assistant Surgeon on James Clarke Ross's *Erebus* and *Terror* expedition and his subsequent work on island Floras. It addressed significant questions regarding the assembly and evolution of island biota and the extent of human impact. The extent to which human impact rather than natural processes explain the diversity patterns observed on islands and how this varies across evolutionary scales remains poorly understood. We propose here that we should recognise this shortfall in our understanding of island diversity as the 'Hookerian shortfall'.

Hooker's interest in islands was rooted in his work with botanical collections: both the collections he himself made on islands and the collections of others that he used to document island diversity. Those historical collections today provide a potential source of data to help understand the scale of the 'Hookerian shortfall' in island biogeographic and evolutionary studies.

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Both authors contributed to the writing of this paper.

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PLANTAS VASCULARES DE MACARONESIA, EXCEPTO CANARIAS, EN EL HERBARIO TFC

Cristina González-Montelongo*, María Catalina León Arencibia*, Jorge Alfredo Reyes-Betancort** & Juan Ramón Acebes Ginovés*

Resumen

El Herbario TFC es el Herbario Institucional de la Universidad de La Laguna (ULL), Tenerife, Islas Canarias y alberga cinco colecciones principales: algas, hongos, líquenes, briófitos y plantas vasculares. La mayor de ellas es la de plantas vasculares con 53 000 pliegos, 890 de ellos recolectados en los archipiélagos macaronésicos de Azores (45 pliegos), Madeira (401), Salvajes (44) y Cabo Verde (400), correspondientes a 91 familias (dominando *Fabaceae*, *Asteraceae*, *Lamiaceae*, *Poaceae* y *Scrophulariaceae*), 279 géneros (dominando *Teline*, *Lavandula*, *Lotus*, *Micromeria* y *Genista*), 396 especies, 19 subespecies, 26 variedades y 1 forma. Están representadas más del 50% de las familias botánicas presentes en los archipiélagos de Salvajes y Cabo Verde. El Herbario TFC presenta al menos un pliego de más de la mitad de endemismos de Cabo Verde y más del 40% de los endemismos de Salvajes.

Palabras clave: herbario TFC, colección de historia natural, Macaronesia, plantas vasculares.

MACARONESIAN (EXCEPT CANARIES) VASCULAR PLANTS IN THE TFC HERBARIUM

Abstract

TFC Herbarium is the Institutional Herbarium of the University of La Laguna (ULL), Tenerife, Canary Islands. TFC herbarium houses five main collections: algae, fungi, lichens, bryophytes and vascular plants. The largest is vascular plants with 53 000 sheets, 890 of them collected in Macaronesian archipelagos of Azores (45 sheets), Madeira (401), Selvagens (44) and Cape Verde (400), of 91 families (principally *Fabaceae*, *Asteraceae*, *Lamiaceae*, *Poaceae* and *Scrophulariaceae*), 279 genera (principally *Teline*, *Lavandula*, *Lotus*, *Micromeria* and *Genista*), 396 species, 19 subspecies, 26 varieties and 1 form. There are present more than 50% of the botanic families of Selvagens and Cape Verde. TFC Herbarium house at least one sheet of more than half of Cape Verde endemisms and more than of 40% of Selvagens endemisms.

Keywords: TFC Herbarium, natural history collection, Macaronesia, vascular plants.

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1. INTRODUCCIÓN

Los herbarios son un recurso de vital importancia para los estudios taxonómicos de vegetales y hongos, siendo una fuente de información de biodiversidad, del presente y pasado de la flora de una determinada región. Actualmente muchos trabajos de evolución, genética, especies invasoras, biología de la conservación, cambio climático, entre otros, se apoyan tanto en el análisis de los especímenes depositados en herbarios como en los datos asociados a ellos (Grass *et al.* 2014, Davis *et al.* 2015, Yoshida *et al.* 2015, Gallinat *et al.* 2018). Estos estudios en auge han conllevado un cambio cualitativo y cuantitativo en el uso tradicional de los herbarios, indispensables cada vez más para otras disciplinas de la ciencia relacionadas con la Botánica, y que han puesto en valor al herbario como herramienta de investigación (Heberling y Isaac 2017). Desafortunadamente, los muestreos destructivos necesarios para algunos de los estudios anteriormente citados entran en conflicto con la conservación del material de herbario. Mientras el personal de los herbarios intenta salvaguardar la integridad de sus colecciones (Rabeler *et al.* 2019), los investigadores desarrollan y aplican nuevas técnicas que permiten desarrollar sus trabajos minimizando el daño producido al material, permitiendo un uso más eficiente de estas colecciones de historia natural (Shepherd 2017). En el caso del Herbario TFC, la normativa de muestreos destructivos es la aceptada por la Asociación de Herbarios Íbero-Macaronésicos (AHIM 2012).

En las últimas décadas han sido muchos los herbarios que se han sumado a la tarea de informatizar los datos de sus especímenes convencidos de la utilidad de los mismos para la comunidad científica. Tanto es así que se espera que en la próxima década los datos de los especímenes de herbario adquieran una importancia aún mayor tanto para la gestión como para la investigación (Baena 2005, Smith y Blagoderov 2012, Lavoie 2013, Holmes *et al.* 2016).

El Herbario TFC, fundado en 1969 (Thiers actualizado continuamente), es el Herbario Institucional de la Universidad de La Laguna (ULL), incluido en los Servicios Generales de Apoyo a la Investigación (SEGAI) y consta de 5 colecciones principales: algas, hongos, líquenes, briófitos y plantas vasculares. La colección de mayor tamaño es la de plantas vasculares, con unos 53 000 pliegos. Aunque principalmente está dedicada a la flora canaria, presenta varias subcolecciones separadas por áreas geográficas: Europa, norte de África, América y Macaronesia, incluyendo esta última únicamente el material de los archipiélagos de Azores, Madeira, Salvajes y Cabo Verde. La tarea de informatización de la colección de plantas vasculares de este herbario se encuentra en una fase inicial (ver Trujillo-Trujillo *et al.* 2014).

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Siendo conscientes de la importancia de dar a conocer el patrimonio biológico de los archipiélagos macaronésicos depositado en el Herbario TFC, se ha llevado a cabo la informatización de los datos asociados a estos especímenes y su análisis. El objetivo principal de nuestra comunicación no es sólo dar a conocer el material de esta colección depositado en el Herbario TFC sino incentivar su uso y consulta por parte de la comunidad científica.

2. MATERIAL Y MÉTODOS

Se han informatizado los datos correspondientes a cada pliego de la colección de Macaronesia, haciendo uso del Gestor de Colecciones Elysia 1.0 de GBIF. ES (Nodo español de «Global Biodiversity Information Facility»), con la intención de publicarlos en el Portal Nacional de Datos de Biodiversidad. Posteriormente, se analizaron los datos referentes a las localidades, hábitats, fecha de recolección, recolector, identificador y otras observaciones (herbario original de procedencia del material en el caso de donaciones, campañas de recolección, etc.), con la finalidad de estudiar la cobertura taxonómica, temporal y espacial siguiendo la metodología de García-Sánchez y Cabezudo (2013), así como la calidad de los datos y la importancia de esta colección de plantas vasculares, empleando los parámetros considerados como descriptores de la importancia de colecciones de herbarios con los que contábamos (Rich 1998). Finalmente, se han comparado los datos obtenidos a través del estudio del material incluido en el herbario con los listados oficiales de biodiversidad de los distintos archipiélagos macaronésicos (Sánchez-Pinto *et al.* 2005; Silva *et al.* 2005; Jardim y Menezes de Sequeira 2008), de los cuales se ha extraído información referente a la presencia insular y grado de endemicidad de las especies y subespecies con al menos un espécimen depositado en el Herbario TFC.

En el marco de este trabajo no se actualizó la nomenclatura utilizada por los especialistas que han identificado el material. Las actualizaciones nomenclaturales automáticas no son una práctica habitual en el trabajo rutinario del Herbario TFC. Éstas se realizan tras la revisión y corrección de la identidad del material por parte de especialistas. Es por esto por lo que se ha mantenido en todo momento los datos que aparecen en las etiquetas originales, o en todo caso los de las etiquetas de revisión.

3. RESULTADOS

El Herbario TFC tiene 890 pliegos de plantas vasculares de los archipiélagos de Azores, Madeira, Salvajes y Cabo Verde.

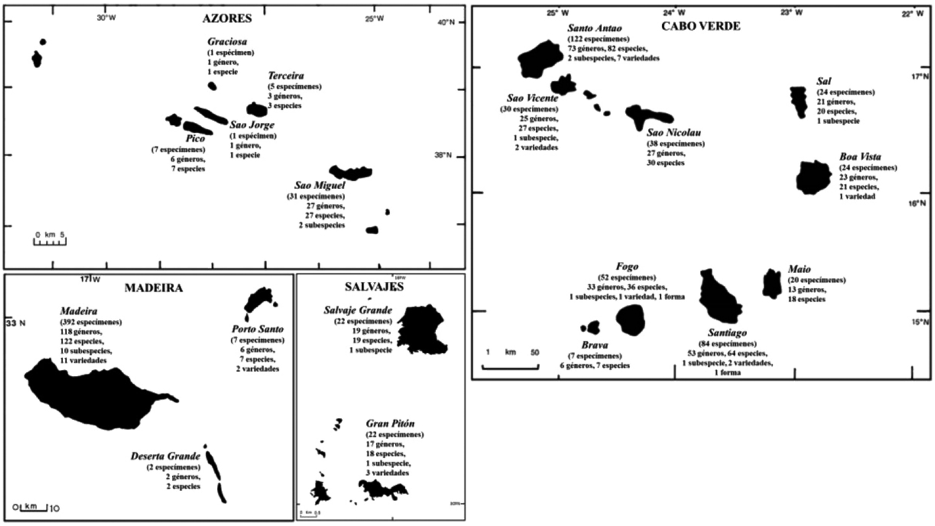

Figura 1. Cobertura espacial de la colección de plantas vasculares de Macaronesia (excepto Canarias) del Herbario TFC. Archipiélagos de Azores, Madeira, Salvajes y Cabo Verde con número de especímenes y taxones por isla presentes en el Herbario TFC.

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 89-116

3.1. Cobertura espacial

Los archipiélagos con mayor número de pliegos en el Herbario TFC son Madeira (401 pliegos) y Cabo Verde (400), seguidos de Azores (45) y Salvajes (44). Hemos encontrado material procedente de 5 islas de Azores (Graciosa, Pico, Terceira, São Jorge y São Miguel), de 3 islas de Madeira (Madeira, Porto Santo y Deserta Grande), de 2 islas de Salvajes (Salvaje Grande y Salvaje Pequeña o Gran Pitón), y de 9 islas de Cabo Verde (Santo Antão, São Vicente, São Nicolau, Sal, Boa Vista, Maio, Santiago, Fogo y Brava) (figura 1).

3.2. Cobertura taxonómica

El material estudiado corresponde a 91 familias, 279 géneros, 396 especies, 19 subespecies, 26 variedades y 1 forma. Las familias con mayor número de especímenes son *Fabaceae* (170 pliegos), *Asteraceae* (114), *Lamiaceae* (106), *Poaceae* (33) y *Scrophulariaceae* (31). Están representadas más del 50% de las familias botánicas presentes en los archipiélagos de Salvajes (60%) y Cabo Verde (50,5%), así como el 40,6% de las presentes en Madeira y un 19,8% de las familias presentes en Azores. Los géneros con mayor número de pliegos son *Teline* (50 pliegos), *Lavandula* (28), *Lotus* (28), *Micromeria* (27) y *Genista* (18), siendo los de mayor

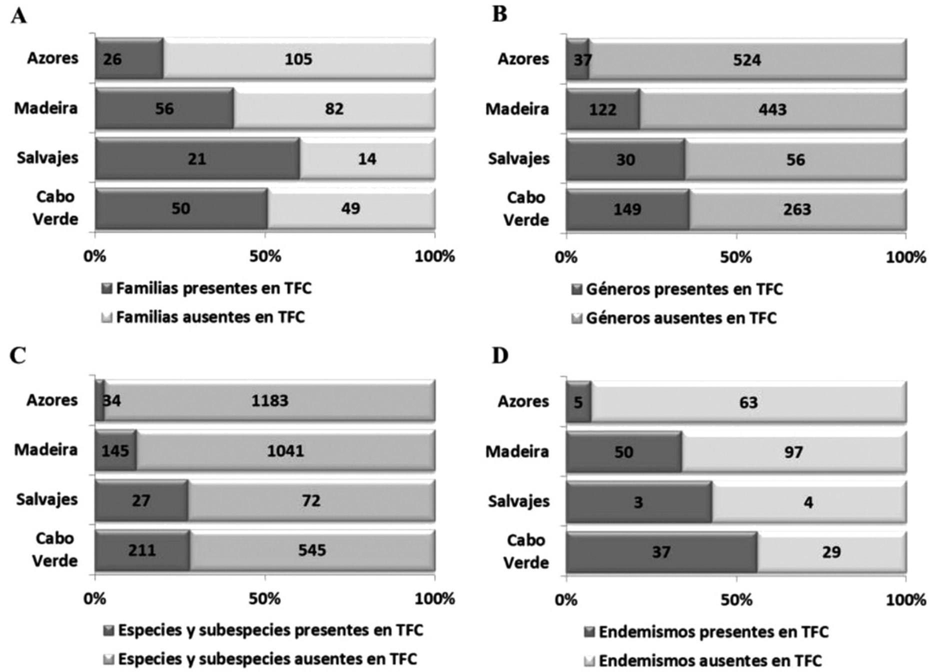

Figura 2. Cobertura taxonómica de la colección de plantas vasculares de Macaronesia (excepto Canarias) del Herbario TFC. Análisis del porcentaje (valores absolutos especificados en las barras) de familias (A), géneros (B), especies y subespecies (C) y endemismos (D) de cada archipiélago macaronésico presentes en el Herbario TFC.

diversidad *Cyperus* (con 9 taxones representados), *Lotus* (8), *Micromeria* (7), *Lavandula* (7) y *Polygonum* (6). Destaca igualmente la representación de géneros de los archipiélagos de Cabo Verde (36,2%) y Salvajes (34,9%) en el Herbario, mientras que los porcentajes de representación de géneros son igualmente menores para los archipiélagos de Madeira (21,6%) y Azores (6,6%). Como era de esperar, la representación específica y subespecífica de cada archipiélago disminuye en porcentajes respecto al de géneros y familias, pero siguen el mismo patrón, destacando como mejor representadas en el Herbario TFC las especies y subespecies de Cabo Verde (27,9%) y Salvajes (27,3%), seguidas por las de Madeira (12,2%) y Azores (2,8%). Por último, y algo más ligado a la conservación de la biodiversidad, es de destacar que el 56,1% de los endemismos de Cabo Verde se encuentran representados con al menos un espécimen en este Herbario. El porcentaje de endemicidad disminuye hasta un 42,9% para el archipiélago de Salvajes, seguido de un 34% para Madeira y un 7,4% para Azores (figura 2).

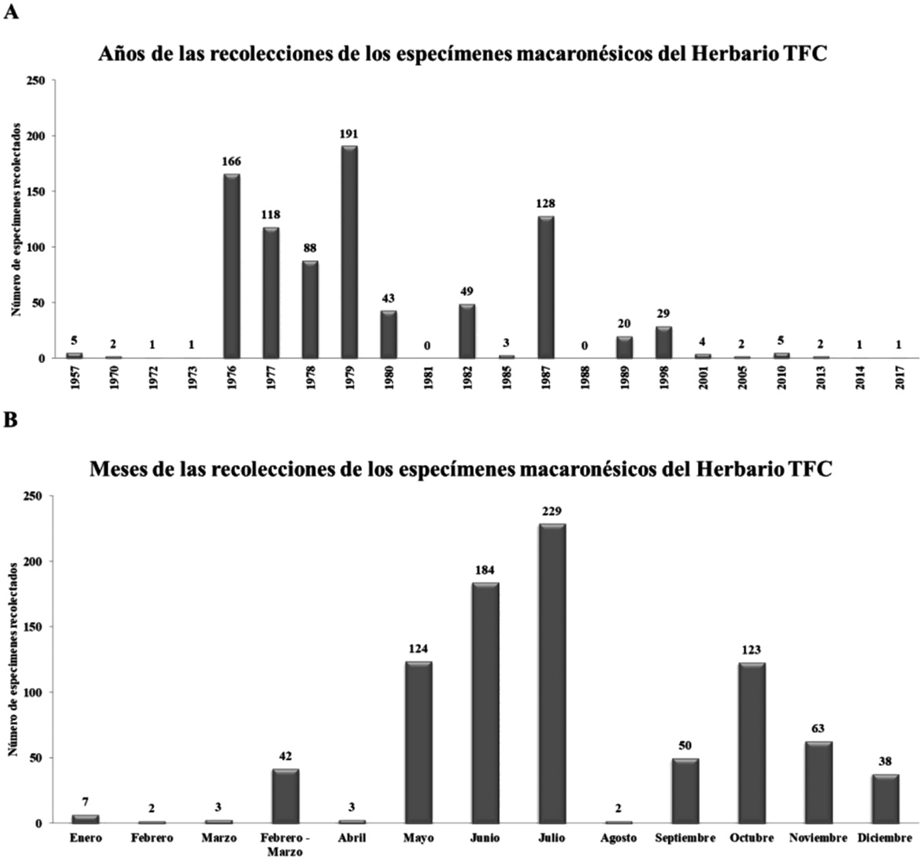

Figura 3. Cobertura temporal de la colección de plantas vasculares de Macaronesia, excepto Canarias, del Herbario TFC. Registro de los años (A) y los meses (B) en los que se han realizado las recolecciones del material. La presencia de un mes extra correspondiente a febrero-marzo se debe a las recolecciones realizadas en la expedición «Agamenón 76» (Salvajes), cuyo material no presenta la fecha exacta de la recolección.

3.3. Cobertura temporal

Las recolecciones más antiguas corresponden a las realizadas por João Vicente Cordeiro Malato-Beliz (1920-1993) en 1957, en Madeira. La mayor producción en cuanto al número de ejemplares recolectados e incorporados finalmente en el TFC, corresponden a los años 70 y 80 del siglo pasado (figura 3a), desarrollándose la mayoría de las recolecciones en los meses de mayo a julio y octubre (figura 3b).

3.4. Calidad de los datos e importancia de la colección

La política del Herbario TFC es incorporar material cuando esté determinado, como mínimo, a nivel genérico. Tan sólo 137 especímenes se encuentran identificados únicamente a nivel genérico, de los cuales sólo 6 especímenes no tienen el género confirmado. El 29,9% del material de esta colección se encuentra sin confirmar su identidad, bien sea a nivel genérico, específico o subespecífico. Prácticamente todo material identificado a nivel específico o infraespecífico presenta la autoría del taxón (faltando tan sólo en 58 registros). Lo mismo ocurre con los datos referentes al lugar de recolección, fecha de recolección y recolector. Por el contrario, la mayoría del material no presenta especificada la autoría de la determinación ni la fecha en la que fue identificado, faltando estos datos en 718 y 853 pliegos, respectivamente. En algunos casos, se puede asignar la identificación al recolector, pero cuando hay varios recolectores, la tarea de identificación no suele ser fácilmente asignable a una única persona.

La colección ha sido objeto de consulta por parte de especialistas y como consecuencia de ello, la identidad de 23 especímenes ha sido corregida. Tan sólo una pequeña parte del material presenta al menos un duplicado establecido. Además, el Herbario TFC es el depositario del *Holotypus* de *Micromeria varia* Bentham subsp. *thymoides* (Solander *ex* Lowe) P. Pérez var. *cacuminicolae* P. Pérez. Otros dos pliegos son materiales testigos de otro tipo de estudio: el TFC 11 304 (*Lavandula pinnata* L.f.) es material testigo de estudio palinológico (muestra P-TFC 695 de la Palinoteca del Herbario TFC) y el TFC 52 657 (*Artemisia gorgonum* Webb) es testigo de estudio de hongos endófitos. Más de la mitad del material (472 especímenes) procede de otros herbarios, tanto institucionales como privados (figura 4).

4. DISCUSIÓN

Hasta ahora, la consulta de los datos correspondientes al material de plantas vasculares recolectado en los archipiélagos macaronésicos requería del estudio del fichero, en soporte físico, o de los pliegos. Gracias a la tarea de informatización llevada a cabo, tanto la consulta como el análisis de estos datos serán más ágiles.

Se verifica el sesgo de recolección espacial, hacia los archipiélagos de Madeira y Cabo Verde, siendo el de Azores el peor representado en el Herbario TFC, así como un sesgo de recolección taxonómica para los géneros *Teline* y *Genista* en cuanto a número de recolecciones, *Cyperus* y *Polygonum* en cuanto a número de taxones representados y *Lavandula*, *Lotus* y *Micromeria* tanto por el número de recolecciones como por el número de taxones representados, recolectado en gran parte en el marco de las tesis doctorales de Pérez de Paz (1978), Del Arco Aguilar (1981) y León Arencibia (1982). La donación de las recolecciones realizadas por Wolfram Lobin en Cabo Verde, de 1978 a 1982, con motivo de su tesis doctoral (Lobin 1982), explica el número de pliegos de Cabo Verde presentes (261 pliegos), lo que explica además los elevados porcentajes de familias, géneros, especies y subespecies caboverdianos, con elevado porcentaje de endemicidad, representados en TFC (Lobin 1982 y Bro-

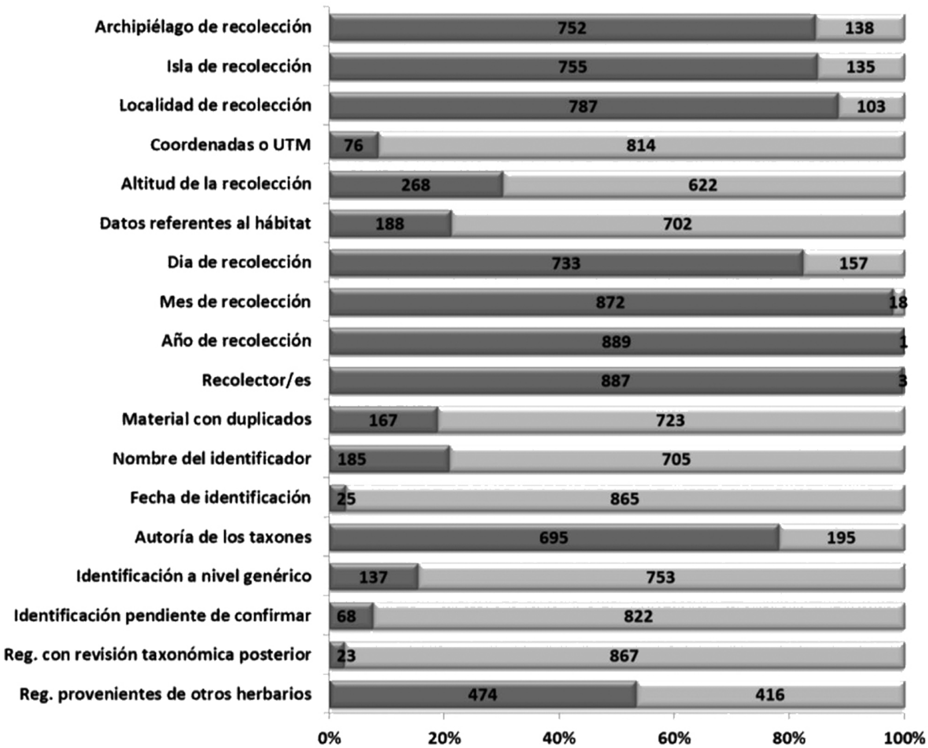

Figura 4. Calidad de los datos. Análisis de la calidad de los datos de recolección e identificación, número de duplicados recolectados, proveniencia del material de herbario y revisiones taxonómicas realizadas al material macaronésico presentes en el Herbario TFC. Se observan, por ejemplo, los elevados porcentajes presentes en las fechas de recolección y el nombre del recolector/es, mientras que destacan los bajos porcentajes de información referente al hábitat y a las coordenadas del lugar de recolección. Sería deseable que los primeros catorce marcadores (Archipiélago de recolección-Autoría de los taxones) presentaran porcentajes próximos al 100%.

chmann *et al.* 1997). A estas recolecciones se les suman las de Cristóbal González-Coviella (1987) donadas al Herbario TFC (126 pliegos).

El volumen de especímenes de Madeira presentes en el Herbario TFC se debe, principalmente, a las recolecciones realizadas por el personal de Botánica de la Universidad de La Laguna, recogidas algunas de ellas en publicaciones de trabajos eminentemente taxonómicos (Del Arco 1982 y 1993, Del Arco *et al.,* 1977, la Serna 1984, la Serna y Saenz 1981), y las de Ø.H. Rustan donadas por el Herbario O (Museo Botánico, Universidad de Oslo). Debemos reseñar la presencia del *Holotypus* de *Micromeria varia* Benth. subsp. *thymoides* (Solander *ex* Lowe) P. Pérez var. *cacuminicolae* P. Pérez, endemismo madeirense, recolectado en julio de 1976 por P. Pérez en «*ex insula Maderae juxta Pico do Arrieiro*» y cuyos duplicados (*Isotypus*) se encuentran depositados en su totalidad en herbarios institucionales fuera del ámbito macaronésico (Herbarios B, BM, FI, P y Z), tal y como reza en la etiqueta del espécimen. Actualmente este nombre ha sido considerado inválido por Puppo y Bräuchler (Puppo y Meimberg 2015) nominándolo *Micromeria maderensis* Puppo y Bräuchler. Por otro lado, una de las funciones que cumple el Herbario TFC es ser depositario del material testigo de trabajos de los grupos de investigación de la Universidad de La Laguna, sean producto de estudios taxonómicos o de otro tipo, caso del pliego de *Artemisia gorgonum* Webb (TFC 52 657) de Cabo Verde, estudiado en una tesis doctoral desarrollada en la ULL (Cosoveanu 2017), y del pliego de *Lavandula pinnata* L.f. (TFC 11 304; P-TFC 695) de Madeira, empleado en estudios palinológicos (León Arencibia y La Serna Ramos 1992).

Los máximos de productividad en cuanto al número de recolecciones realizadas corresponden a expediciones y al desarrollo de tesis doctorales con enfoque taxonómico, desarrolladas principalmente en la década de los 70: Acebes Ginovés y Pérez de Paz en Madeira y Salvajes (1976), Wildpret de la Torre, Pérez de Paz, Del Arco Aguilar y La Serna Ramos en Madeira (1977), Rustan en Madeira (1978) y Lobin en Cabo Verde (1978-1979). Posteriormente, en 1987, se dio un nuevo pico de recolección debido a la actividad desarrollada por González-Coviella en Cabo Verde. Los meses más exitosos en recolecciones corresponden fundamentalmente con la época favorable para el estudio botánico, final de primavera-inicio del verano, momento en el que las plantas presentan en estado óptimo los caracteres diagnósticos que permiten su identificación. El material recolectado en «febrero-marzo» corresponde, en su totalidad, a las recolecciones desarrolladas en el año 1976, fundamentalmente por los investigadores del Departamento de Botánica, Ecología y Fisiología Vegetal de la ULL Pedro Luis Pérez de Paz y Juan Ramón Acebes Ginovés, en el marco de la expedición «Agamenón 76» del 23 de febrero al 3 de marzo de 1976 al archipiélago de Salvajes (Acebes Ginovés y Pérez de Paz 1984 y Pérez de Paz y Acebes Ginovés 1983). En las últimas décadas las incorporaciones de material macaronésico en el Herbario TFC han disminuido considerablemente, fundamentalmente por la prácticamente ausencia de proyectos y tesis doctorales taxonómicas desarrolladas en el Área de Botánica, así como por la imposibilidad de realizar intercambios con otros herbarios de la región macaronésica debido a la falta de espacio para albergar nuevas recolecciones.

Aunque la colección estudiada sea pequeña en cuanto a número de especímenes, éstos pueden ser en el futuro estudiados nuevamente y re-identificados, e incluso ser el material que ponga sobre la pista a los taxónomos sobre la presencia de nuevos taxones que habitan en estos archipiélagos, ya que sabemos que muchos nuevos taxones pasan desapercibidos en los herbarios incluso varias décadas antes de ser descubiertas y descritas como novedades científicas (Bebber *et al.* 2010).

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A todos aquellos recolectores y herbarios institucionales que han permitido tener la actual colección de plantas vasculares de los archipiélagos de Azores, Madeira, Salvajes y Cabo Verde en el Herbario TFC. Agradecemos las aportaciones de dos revisores anónimos que han ayudado a mejorar el manuscrito.

6. CONTRIBUCIÓN DE LOS AUTORES

Conceptualización: CGM.
Metodología: CGM, MCLA y JRAG.
Análisis de datos: CGM.
Preparación del escrito original: CGM.
Corrección y edición del escrito definitivo: CGM, JRAG, MCLA y JARB.

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ANEXO I: LISTADO DE ESPECIES MACARONÉSICAS CON REPRESENTACIÓN EN EL HERBARIO TFC

Taxones representados en el Herbario TFC de las islas de los archipiélagos de Azores (G: Graciosa, P: Pico, SJ: São Jorge, T: Terceira, SM: São Miguel), Madeira (M: Madeira, D: Desertas, PS: Porto Santo), Salvajes (SG: Salvaje Grande, GP: Gran Pitón) y Cabo Verde (SA: Santo Antão, SV: São Vicente, SN: São Nicolau, S: Sal, B: Boavista; M: Maio, T: Santiago, F: Fogo, Br: Brava). Se ha uniformado las paternidades de los taxones haciendo uso de la base de datos «*International Plant Names Index* (IPNI 2019)».

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Abrus precatorius L.													+						
Acanthospermum hispidum DC.																+			
Adenocarpus complicatus (L.) J.Gay *ex* Gren. & Godr.						+													
Adiantum capillus-veneris L.													+						
Adiantum hispidulum Sw.					+														
Ageratum conyzoides L.												+							
Agropyron junceiforme (Á.Löve *et* D.Löve) Á. Löve *et* D.Löve										+									
Aichryson divaricatum (Aiton) Praeger						+													
Aichryson villosum (Aiton) Webb *et* Berthel.						+													
Aizoon canariense L.									+	+	+								
Ajuga iva (L.) Schreb. var. *pseudoiva* (Robill. *et* Cast. *ex* DC.) Robill. *et* Cast. *ex* Bentham																	+		
Alternanthera caracasana Humb., Bonpl. *et* Kunth											+								
Alternanthera sessilis (L.) DC.											+								
Alysicarpus ovalifolius (Schumach.) J.Léonard												+							
Amaranthus hybridus L.												+							
Anagallis arvensis L. f. *azurea* Hyl.												+						+	
Andrachne telephioides L. var. *rotundifolia* (C.A. Mey) Muell. Arg.															+				

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Andryala glandulosa Lam. subsp. *glandulosa*						+													
Anthyllis lemanniana Lowe						+													
Arabis alpina L. subsp. *caucasica* (Willd.) Briq.						+													
Arachis hypogaea L.																		+	
Aristida adscensionis L.											+								
Aristida funiculata Trin. *et* Rupr.											+			+					
Armeria maderensis Lowe						+													
Artemisia argentea L'Hér.						+													
Artemisia gorgonum Webb *in* Hook.											+	+							
Arthrocnemum glaucum (Delarb.) Ung.-Stemb.														+					
Asparagus nesiotes Svent.										+									
Asparagus squarrosus J.A. Schmidt											+						+		
Asphodelus fistulosus L.											+							+	
Asplenium billotii F. Schultz					+														
Asplenium hemionitis L.		+																	
Asplenium marinum L.					+	+													
Asplenium onopteris L. var. *onopteris*						+													
Asteriscus smithii (Webb) Walp.													+						
Asteriscus vogelii (Webb) Walp.											+						+		
Asterolinum linum-stellatum (L.) Duby									+										
Astragalus vogelii (Webb) Bornm.														+					
Astydamia latifolia (L.f.) Baill.									+										
Atriplex halimus L.															+				
Bassia tomentosa (Lowe) Maire *et* Weiller										+									
Berberis maderensis Lowe						+													
Beta procumbens C. Sm. *ex* Hornem.										+									
Bidens bipinnata L.												+							

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Bidens pilosa L.												+							
Blechnum spicant (L.) Roth						+													
Boerhavia diffusa L.											+								
Borreria verticillata (L.) G. Mey.												+							+
Brachypodium sylvaticum (Huds.) P. Beauv.											+								
Brassica nigra (L.) W.D.J. Koch *in* Roehl																	+		
Briza maxima L.						+													
Bulbostylis barbata (Rottb.) C.B. Clarke																		+	
Bystropogon canariensis (L.) L'Hèr.						+													
Bystropogon maderensis Webb *et* Berthel.						+													
Calamintha chenopodium Roth.						+													
Calamintha sylvatica Bromf. subsp. *ascendens* (Jord.) P.W. Ball						+													
Calceolaria chelidonioides Kunth						+													
Calceolaria tripartita Ruiz *et* Pav.						+													
Calendula maderensis DC.						+	+												
Calluna vulgaris (L.) Hull					+														
Campanula jacobaea C. Sm. *ex* Webb *in* Hook.											+	+							
Campylanthus glaber Benth. *in* DC.											+		+						
Campylanthus spathulatus A. Chev.											+								
Carex antoniensis A. Chev.											+								
Carlina salicifolia (L.f.) Cav.						+													
Cassia absus L.											+								
Cassia mimosoides L.																		+	
Cassia siamea Lam.												+							
Cedronella canariensis (L.) Webb *et* Berthel.						+													
Cenchrus ciliaris L.											+		+				+		
Centaurea melitensis L.						+													

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Centaurium tenuiflorum (Hoffmanns. *et* Link) Fritsch subsp. *viridense* (Bolle) A. Hansen *et* Sunding												+							
Cerastium glomeratum Thuill.												+							
Chamaecytisus proliferus (L.f.) Link																		+	
Chamaemeles coriacea Lindl.						+													
Chelidonium majus L.						+													
Chenopodium ambrosioides L.											+								
Chenopodium murale L.									+	+									
Christella dentata (Forssk.) Brownsey *et* Jermy											+								
Chrysanthemum pinnatifidum L.f. var. *thalassophilum* Svent.										+									
Cistanche phelypaea (L.) Cout.									+										
Cleome scaposa DC.														+					
Cleome viscosa L.												+							
Clethra arborea Aiton						+													
Clinopodium vulgare L.						+													
Clinopodium vulgare L. subsp. *arundanum* (Boiss.) Nyman						+													
Cocculus pendulus (G. Forst.) Diels												+							
Commelina benghalensis L.																		+	
Convolvulus massonii F. Dietr.						+													
Conyza bonariensis (L.) Cronquist												+						+	+
Conyza feae (Beg.) Wild											+								
Conyza varia (Webb) Wild											+		+						
Corchorus depressus (L.) Stocks											+								
Corchorus tridens L.																		+	
Crambe fruticosa L.f.						+													
Cressa cretica L.														+	+				
Crotalaria goreensis Guill. *et* Perr. var. *macrostipula* (Steud.) Bak. Fil.												+							
Crotalaria microphylla Vahl														+					

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Crotalaria retusa L.												+							
Crotalaria senegalensis Bacle												+	+		+				
Cryptomeria japonica D. Don					+														
Cuscuta epithymum (L.) L.									+										
Cyperus alternifolius L.													+						
Cyperus amabilis Vahl																		+	
Cyperus articulatus L.																+			
Cyperus bulbosus Vahl														+		+			
Cyperus cadamosti Bolle																+			
Cyperus esculentus L.																		+	
Cyperus laevigatus L.												+					+		
Cyperus maritimus Poir.																+			
Cyperus rotundus L.												+							
Cystopteris fragilis (L.) Bernh.		+		+	+														
Dactylis smithii Link						+													
Dactylorhiza foliosa (Sol. *ex* Lowe) Soó						+													
Dalechampia scandens L.						+													
Desmodium scorpiurus (Sw.) Desv.												+						+	
Desmodium tortuosum (Sw.) DC.											+	+							
Dichanthium annulatum (Forssk.) Stapf														+					
Dicliptera verticillata (Forssk.) C. Chr.													+						
Digitalis purpurea L.						+													
Diplotaxis glauca (J.A. Schmidt) O.E. Schulz														+					
Diplotaxis gracilis (Webb) O.E. Schulz											+								
Diplotaxis vogelii (Webb) Cout.											+						+		
Dolichos daltonii Webb												+						+	
Echium candicans L.f.						+													
Echium hypertropicum Webb												+							
Echium stenosiphon Webb											+								
Echium stenosiphon Webb subsp. *stenosiphon*																	+		

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Eclipta prostrata (L.) L.																			+
Egeria densa Planch.					+														
Elaphoglossum pahaceum (Hooker *et* Grev.) Sledge		+																	
Elvira biflora (L.) L.												+							
Enneapogon desvauxii Sm.											+								
Epilobium hirsutum L.											+	+							
Equisetum ramosissimum Desf.													+						
Eremopogon foveolatus (Delile) Stapf											+								
Erica arborea L.					+	+													
Erica maderensis (Benth.) Bornm.						+													
Erysimum bicolor (Hornem.) DC.						+													
Erysimum caboverdeanum (A.Chev.) Sunding																		+	
Euphorbia forskaolii J. Gay															+	+			
Euphorbia hirta L.											+	+							
Euphorbia prostrata Aiton											+	+							
Evolvulus alsinoides L.											+	+			+				
Fagonia cretica L.										+	+								
Fagonia isotricha Murb.											+								
Festuca albida Lowe						+													
Fimbristylis debilis Steud.															+				
Fimbristylis ferruginea (L.) Vahl											+								
Fimbristylis hispidula (Vahl) Kunth												+							
Flaveria bidentis (L.) Kuntze																+	+		
Forsskaolea procridifolia Webb											+			+			+		
Frankenia ericifolia C. Sm.											+			+			+		
Frankenia ericifolia C. Sm. var. *ericifolia*																	+		
Frankenia laevis L.								+		+									
Frankenia pulverulenta L.					+														
Fuirena ciliaris (L.) Roxb.															+				
Galinsoga ciliata (Rafin) S.F. Blake													+						

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Galinsoga parviflora Cav.																		+	
Galium parisiense L.													+						
Galium productum Lowe						+													
Galium scabrum L.						+													
Genista tenera (Jacq. *ex* Murray) Kuntze						+													
Gennaria diphylla (Link) Parl.						+													
Geranium palmatum Cav.						+													
Glinus lotoides L.																	+		
Globularia amygdalifolia Webb											+								
Globularia salicina Lam.						+													
Gnaphalium luteo-album L.						+						+						+	
Gnidia polystachya P.J. Bergius						+													
Gynandropsis gynandra (L.) Briq.																+			
Helianthemum gorgoneum Webb											+								
Helichrysum melaleucum Rchb. *ex* Holl						+													
Heliotropium curassavicum L.															+				
Heliotropium ramosissimum (Lehm.) DC.											+			+			+		
Heteropogon contortus (L.) Roem. *et* Schult.																	+		
Huperzia selago (L.) Bernh. *ex* Schrank *et* Mart. subsp. *dentata* (Herter) Valentine					+	+													
Hymenophyllum tunbrigense (L.) Sm.		+																	
Hyparrhenia hirta (L.) Stapf											+								
Hypericum elodes L.					+														
Hypericum foliosum Aiton					+														
Hypodematium crenatum (Forssk.) Kuhn											+								
Indigofera colutea (Burm. f.) Merr.												+							
Indigofera cordifolia B. Heyne *ex* Roth															+	+		+	
Indigofera hirsuta L.												+						+	

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Indigofera parviflora B. Heyne *ex* Wight *et* Arn.												+	+	+					
Indigofera senegalensis Lam.																+			
Indigofera subulata Poir.												+							
Ipomoea cairica (L.) Sweet																		+	
Ipomoea coptica (L.) Roth *ex* Roem. *et* Schult.															+				
Ipomoea eriocarpa R. Br.												+				+		+	
Jasminum odoratissimum L.						+													
Juncus acutus L.											+						+		
Kickxia brunneri (Benth.) Janch.											+		+	+					
Kickxia dichondrifolia (Benth.) Sunding											+								
Kohautia aspera (Heyne *ex* Roth) Bremek.																		+	
Kyllinga pumila Michx.												+							
Kyllinga squamulata Thonn. *ex* Vahl												+							
Launaea arborescens (Batt.) Murb.																+			+
Launaea nudicaulis (L.) Hook. f.													+		+				
Launaea picridioides (Webb) Engl.											+		+				+		+
Laurus azorica (Seub.) Franco		+			+	+													
Lavandula dentata L.											+								
Lavandula dentata L. var. *rendalliana* Bolle											+								
Lavandula latifolia Medik.						+													
Lavandula pinnata L.f.						+													
Lavandula rotundifolia Benth.											+	+	+				+	+	
Lavandula rotundifolia Benth. var. *subpinnatifida* Chev.											+								
Lavandula stricta Delarb.											+		+				+		
Leontodon rigens (Dryand.) Paiva *et* Ormonde					+														
Lepidium sativum L.												+							
Limonium braunii (Bolle) A. Chev.											+								

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Limonium jovibarba (Webb) Kuntze																	+		
Limonium papillatum (Webb *et* Berth.) O. Kuntze var. *callibotryum* Svent.										+									
Limonium vulgare Mill. subsp. *serotinum* (Rchb.) Gems.					+														
Linum trigynum L.						+													
Lobelia urens L.				+															
Lobularia canariensis (DC.) L. Borgen subsp. *succulenta* L. Borgen										+									
Lobularia canariensis (DC.) L. Borgen aff. subsp. *succulenta* L. Borgen									+										
Lobularia canariensis (DC.) L.Borgen subsp. *fruticosa* (Webb) L. Borgen											+								
Lophochloa cristata (L.) H. Hyl.								+											
Lotononis platycarpa (Viv.) Pic.Serm.											+								
Lotus arborescens Lowe *ex* Cout.													+						
Lotus brunneri Webb *in* Hook.													+				+		
Lotus glaucus Aiton						+													
Lotus glaucus Aiton var. *glaucus*								+											
Lotus jacobaeus L.											+			+					
Lotus loweanus Webb *et* Berthel.								+											
Lotus salvagensis R.P. Murray										+									
Lotus uliginosus Schkuhr						+													
Luzula multiflora (Retz.) Lej.						+													
Lycopersicon esculentum Mill.									+										
Lycopodiella cernua (L.) Pic. Serm.				+	+														
Lysimachia azorica Hornem. *ex* Hook.					+														
Mariscus alternifolius Vahl												+							
Mariscus squarrosus (L.) C.B. Clarke															+				

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Maytenus dryandri (Lowe) Loes.						+													
Melanoselinum decipiens (Schrad. *et* J.C. Wendl.) Hoffm.						+													
Melhania ovata (Cav.) Spreng.																		+	
Mesembryanthemum nodiflorum L.									+										
Micromeria forbesii Benth.											+	+	+					+	+
Micromeria forbesii Benth. var. *altitudinum* Bolle											+								
Micromeria forbesii Benth. var. *inodora* Schmidt											+								
Micromeria varia Benth. subsp. *thymoides* (Sol. *ex* Lowe) P. Pérez						+													
Micromeria varia Benth. subsp. *thymoides* (Sol. *ex* Lowe) P. Pérez var. *cacumini-colae* P. Pérez						+													
Micromeria varia Benth. subsp. *thymoides* (Sol. *ex* Lowe) P. Pérez var. *thymoides*						+		+											
Misopates orontium (L.) Raf.											+								
Mitracarpus villosus (Sw.) DC.																		+	
Mollugo nudicaulis Lam.													+			+		+	
Mollugo verticillata L.												+							
Musschia aurea (L.f.) Dumort.						+													
Myosotis discolor Pers. subsp. *canariensis* (Pit.) Grau						+													
Myrica faya Aiton					+	+													
Myrtus communis L.						+													
Odontites holliana (Lowe) Benth.						+													
Oenothera rosea L'Hér. *ex* Aiton											+								
Oldenlandia corymbosa L.																		+	
Oldenlandia herbacea (L.) Roxb.																		+	
Olea europaea L. var. *made-rensis* Lowe						+													

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Origanum virens Hoffmanns. *et* Link								+											
Parietaria debilis G.Forst.											+								
Paronychia illecebroides (C. Sm. *ex* Webb) Webb											+		+				+	+	
Paronychia illecebroides (C.Sm. *ex* Webb) Webb var. *illecebroides*											+								
Patellifolia procumbens (C. Sm. *ex* Hornem.) A.J.Scott, Ford-Lloyd *et* J.T. Williams											+								
Pegolettia senegalensis Cass.											+			+		+			
Pericallis aurita (L'Hér.) B. Nord.						+													
Periploca chevalieri Browicz													+						
Peristrophe bicalyculata (Retz.) Nees												+							
Phagnalon melanoleucum Webb *in* Hook.											+							+	
Phyllanthus amarus Schu-mach. *et* Thonn.											+								
Phyllanthus rotundifolius J.G. Klein *ex* Willd.											+								
Phyllis nobla L.						+													
Phytolacca americana L.											+								
Pittosporum undulatum Vent.					+														
Plantago arborescens Poir.						+													
Plantago arborescens Poir. subsp. *maderensis* (Decne.) A. Hansen *et* G. Kunkel						+													
Plantago coronopus L.									+	+									
Plantago psyllium L. var. *obtusata* Svent.										+									
Plantago subspathulata Pilg.						+													
Pluchea ovalis (Pers.) DC.											+	+							
Plumbago zeylanica L.												+							
Polycarpaea gayi Webb											+		+					+	
Polycarpaea nivea (Aiton) Webb														+					
Polycarpon tetraphyllum (L.) L.																			+

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Polygonum capitatum Buch.-Ham. *ex* D. Don					+														
Polygonum maritimum L.						+													
Polygonum salicifolium Brouss. *ex* Willd.						+						+							
Polypogon maritimus Willd.							+												
Polypogon monspeliensis (L.) Desf.											+								
Polypogon semiverticillatus (Forssk.) Hyl.																	+		
Polypogon viridis (Gouan) Breistr.											+								
Potamogeton antaicus Hagstr.											+		+						
Prasium majus L.						+													
Prunella vulgaris L.					+	+													
Pulicaria burchardii Hutch. subsp. *longifolia* E. Gamal-Eldin														+					
Pycreus mundtii Nees												+							
Pycreus polystachyos (Rottb.) P. Beauv.											+	+							
Rhamnus glandulosa Aiton						+													
Rhynchosia minima (L.) DC.															+			+	
Rhynchosia minima (L.) DC. var. *memnonia* (Delile) T. Cooke																		+	
Rubia fruticosa Aiton									+										
Rumex maderensis Lowe						+													
Ruppia maritima L.												+		+					
Ruscus streptophyllus Yeo						+													
Salsola kali L.								+											
Salvia aegyptiaca L.																	+		
Salvia coccinea Juss. *ex* Murray											+								
Sambucus ebulus L.						+													
Samolus valerandi L.						+					+	+	+				+		
Sarcostemma daltonii Decne.											+								
Saxifraga maderensis D. Don						+													
Schizogyne sericea (L.f.) DC.									+										
Schoenefeldia gracilis Kunth															+				

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Scirpus grandispicus (Steud.) Berhaut															+				
Sclerocephalus arabicus Boiss.											+								
Scrophularia arguta Soland.									+		+	+							
Scrophularia scorodonia L.					+														
Sedum farinosum Lowe						+													
Sedum nudum Aiton subsp. *nudum*						+													
Semele androgyna (L.) Kunth						+													
Senecio incrassatus Lowe									+	+									
Senecio maderensis DC.						+													
Sesbania bispinosa (Jacq.) W. Wight															+				
Setaria adhaerens (Forssk.) Chiov.														+			+		
Setaria pumila (Poir.) Roem. *et* Schult.					+														
Sibthorpia peregrina L.						+													
Sideritis candicans Aiton						+													
Sideritis candicans Aiton var. *candicans*						+													
Sideroxylon marmulano Banks *ex* Lowe												+					+		
Sideroxylon marmulano Banks *ex* Lowe var. *marmu-lano*						+													
Silene gallica L.												+							
Sinapidendron angustifolium (DC.) Lowe						+													
Sinapidendron frutescens (Sol. *in* Aiton) Lowe var. *frutescens*						+													
Sinapidendron rupestre Lowe						+													
Sonchus fruticosus L.f.						+													
Sonchus oleraceus L.									+			+							
Sorbus maderensis (Lowe) Dode						+													
Spergularia azorica (Kindb.) Lebel		+																	
Spergularia fallax Lowe									+										
Borreria verticillata (L.) G. Mey.																		+	

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Sporobolus minutus Link																+			
Sporobolus spicatus (Vahl) Kunth														+	+	+			
Stylosanthes fruticosa (Retz.) Alston												+						+	
Suaeda vera Forssk. *ex* J.F. Gmel									+	+									
Synedrella nodiflora (L.) Gaertn.													+					+	
Tagetes minuta L.											+		+						
Tamarix canariensis Willd.															+				
Tamarix gallica L.						+													
Tamarix senegalensis DC.											+								
Teline maderensis Webb *et* Berthel.						+													
Teline maderensis Webb *et* Berthel. var. *maderensis*						+													
Teline maderensis Webb *et* Berthel. var. *paivae* (Lowe) del Arco						+													
Tephrosia bracteolata Guill. *et* Perr.												+						+	
Tephrosia pedicellata Baker *in* Oliv.												+							
Tephrosia purpurea (L.) Pers. subsp. *leptostachya* (DC.) Brummitt																		+	
Tephrosia uniflora Pers.												+			+	+		+	
Teucrium abutiloides L'Hér.						+													
Teucrium betonicum L'Hér.						+													
Thymus caespititius Brot.						+													
Tolpis azorica (Nutt.) P. Silva					+														
Tolpis fruticosa Schrank						+													
Tolpis succulenta (Dryand. *in* Aiton) Lowe						+													
Tornabenea hirta J.A.Schmidt											+								
Trachelium caeruleum L.						+													
Tribulus cistoides L.											+								
Trichodesma africanum (L.) Lehm.											+								
Tricholaena teneriffae (L.f.) Link											+								

	G	P	SJ	T	SM	M	D	PS	SG	GP	SA	SV	SN	S	B	M	T	F	Br
Trichomanes speciosum Willd.					+														
Trifolium glomeratum L.											+								
Triumfetta pentandra A.Rich.											+								
Umbilicus rupestris (Salisb.) Dandy						+													
Urospermum picroides (L.) Scop. *ex* F.W. Schmidt												+							
Urtica membranacea Poir.									+										
Vaccinium maderense Link						+													
Vaccinium padifolium Sm.						+													
Vandenboschia speciosa (Willd.) Copel	+		+																
Verbascum capitis-viridis Hub.-Mor.											+	+							
Vicia capreolata Lowe						+													
Vicia leptoclada (Webb) Dandy															+				
Vicia sativa L.						+													
Vicia tenuissima (Bieb.) Schinz. *et* Thell.						+													
Viola paradoxa Lowe						+													
Viola riviniana Rchb.						+													
Visnea mocanera L.f.						+													
Wahlenbergia lobelioides (L.f.) Link									+										
Wahlenbergia lobelioides (L.f.) A. DC. subsp. *lobelioides*											+								
Waltheria indica L.												+						+	
Zaleya pentandra (L.) C. Jeffrey											+								
Zinnia peruviana (L.) L.												+				+			
Ziziphus mauritiana Lam.												+							
Zornia glochidiata Rchb. *ex* DC.												+							
Zygophyllum fontanesii Webb *et* Berthel.										+									
Zygophyllum simplex L.													+						

WELCOME TO MIGRANTS IN A BORDERLESS EUROPE: BRYOPHYTES SHOW THE WAY TO GO

Alain Vanderpoorten*, Alice Ledent**
& Jairo Patiño***

Abstract

Reconstructing the Quaternary history of European bryophytes has long been challenging because, except for macro-remains preserved in peat, the fossil record is extremely poor as compared to vascular plants. Coalescent simulations revealed that the postglacial assembly of European bryophytes involves a complex history from multiple sources, contrasting with the prevailing model of northwards species migration from Mediterranean refugia. A scenario of extra-European postglacial recolonization clearly emerged as dominant. A bulk of the bryoflora that pre-existed in Europe before the Ice Age was reinforced by allochthonous migrants. The Atlantic European fringe was, in contrast, de novo colonized by species primarily distributed across tropical areas. We hypothesize that, for the particular case of the oceanic bryophyte floristic element, the Macaronesian islands represented a mandatory stepping-stone situated midway between the tropics and Europe due to the necessity for tropical species to pre-adapt under insular warm-temperate conditions before they successfully establish in temperate regions.

Keywords: Approximate Bayesian computation, bryophytes, climate change, dispersal, historical biogeography, Last Glacial Maximum, refugia.

BIENVENIDA A LOS MIGRANTES A UNA EUROPA SIN FRONTERAS: LOS BRIÓFITOS MUESTRAN EL CAMINO A SEGUIR

Resumen

La reconstrucción de la historia cuaternaria de los briófitos europeos ha supuesto un reto durante mucho tiempo, ya que, a excepción de restos macroscópicos preservados en turberas, el registro fósil es excepcionalmente escaso en comparación con el de plantas vasculares. Análisis de coalescencia revelaron que el ensamblaje postglacial de las comunidades de briófitos europeos es compleja e incluye múltiples orígenes, contrastando con el modelo clásico de apunta al predominio de una migración hacia el norte desde refugios mediterráneos. Una parte significativa de la flora de Europa preexistente antes de la Edad del Hielo fue reforzada por inmigrantes alóctonos. Sin embargo, la Franja Atlántica europea fue principalmente colonizada por especies tropicales. Se postula que para el elemento florístico oceánico de briófitos, Macaronesia ha jugado un papel como 'stepping-stone' hacia Europa, un paso imprescindible para que especies tropicales puedan preadaptarse bajo los típicos regímenes climáticos suaves insulares, antes de establecerse en regiones templadas.

Palabras clave: computación bayesiana, briófitos, cambio climático, dispersión, biogeografía histórica, último máximo glacial, refugios.

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1. INTRODUCTION

The Quaternary period has been characterized by high amplitude climatic oscillations leading to glacial/interglacial cycles in both hemispheres, rapid sea-level changes (up to 140 m), and megafaunal extinctions on all continents (Pillans and Gibbard 2012). The duration of each glacial/interglacial cycle varied through time. From the beginning of the Quaternary (*i.e.* 2.7 million years ago termed as Ma) to 0.9 Ma, the duration of a cycle was *c.* 41 thousand years (Kyrs). It then expanded to a *c.* 100 Kyrs, which is the duration still observed now. Each cycle included a long glacial period and a short interglacial period. During the entire Quaternary period, there were around 40 to 50 glacial periods and the areas located beyond 65° of latitude towards the poles were always covered in ice, while temperate areas right below those latitudes, were, more or less widely, covered in ice only during glacial periods (Berger et al., 2012). Although the Penultimate Last Glacial Maximum (*c.* 140 Kyrs ago, PLGM) (Schneider et al., 2013) involved globally larger ice-sheets, current species distributions were mostly shaped by the Last Glacial Maximum (LGM, *c.* 22 Kyrs ago) (Clark et al., 2009; Hewitt 2000). Indeed, the LGM was not only characterized by large ice-sheets, but also by a very dry climate around the globe, as evidenced, in Eurasia, by paleo-vegetation reconstructions based on pollen records describing this part of the world as mostly treeless, with a dominance of steppe, tundra and other xeric types of vegetations (Tzedakis et al., 2013; Wu et al., 2007).

Europe has long served as a model to study the impact of climate change on species distribution (Lumibao et al., 2017). The classical demographic scenario, the "southern refugium scenario" (Fig. 1), is based on paleontological and phylogeographic evidence and suggests that species persisted in Mediterranean refugia during glacial periods, from which they recolonized northern areas during interglacial periods (Hewitt 1996, 1999, 2000, 2004; Médail and Diadema 2009). The "northern refugium scenario" (Fig. 2) alternatively proposes that species persisted within micro-refugia located between the ice-sheet and the main southern mountain ranges during glacial periods, from where they back-colonized northern areas (Bhagwat and Willis 2008).

In the present review, we focus on the impact of LGM climate change in bryophytes. Bryophytes are non-vascular plants, which means that they cannot pump-up water from the soil, but instead absorb water and nutrients from their entire surface directly from rainfall and atmospheric humidity. Unlike vascu-

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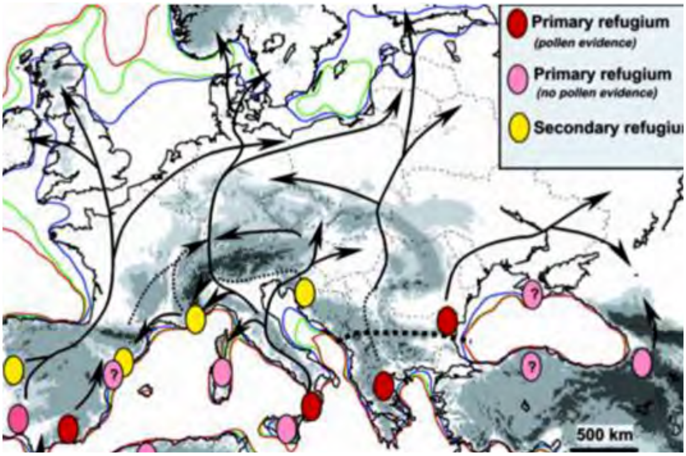

Fig. 1. Southern glacial refugia and major post-glaciation migration routes of white oaks in Europe (reproduced from Petit et al. 2002).

lar plants, which are drought-resistant and aim at maintaining sufficient levels of water during periods of drought thanks to the presence of a waterproof cuticle and the regulation of gas exchange through their stomata, bryophytes are poïkilohydric, *i.e.*, drought-tolerant. This means that they dry-out with ambient air, become dormant under dry conditions and resume physiological activity upon moistening. Bryophytes are therefore very sensitive to variations of the precipitation regime (He et al., 2016). Furthermore, bryophytes globally exhibit a very high cold tolerance. Recent evidence pointed to their ability of in-vitro regeneration after hundreds to thousands of years in ice (La Farge et al., 2013; Roads et al., 2014), supporting the application of the northern refugium hypothesis in the group. Bryophytes are also very efficient dispersers (see Patiño and Vanderpoorten 2018 for review), and these high long-distance capacities raise the intriguing idea that postglacial recolonization could have taken place from geographically remote areas. In Europe for instance, mounting evidence points to the relevance of Macaronesian islands (Hutsemékers et al., 2011; Laenen et al., 2011) and North America (Stenøien et al., 2011) as sources of recolonizing propagules.

Reconstructing the Quaternary history of European bryophytes has long been a challenging issue because, except for macro-remains preserved in peat, the fossil record is extremely poor as compared to vascular plants (see Patiño and Vanderpoorten 2018 for review), calling for a molecular phylogeographic approach. Although several species-specific studies have been published (see Kyrkjeeide et al., 2014 for review), there has been to date no comprehensive effort to reconstruct the Quaternary history of bryophytes. Here, we review most recent phylogeographic evidence (Patiño et al., 2015; Ledent et al., 2019) to show that post-glacial recolo-

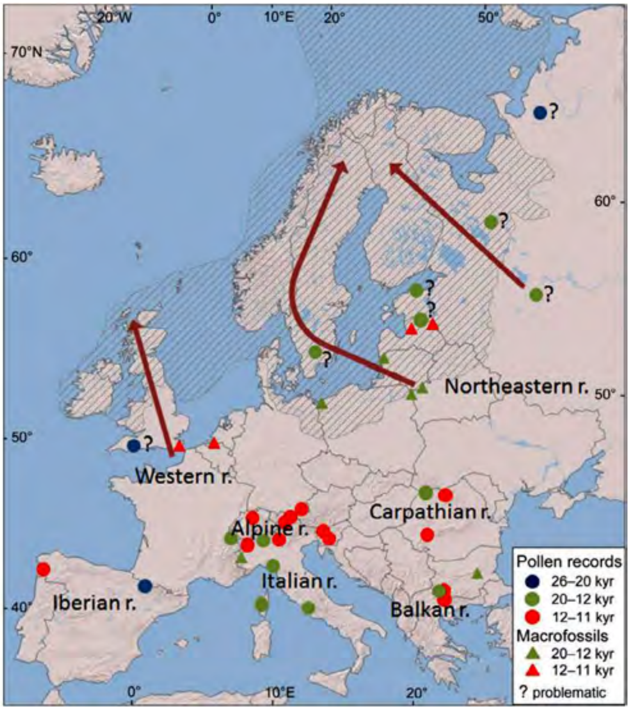

Fig. 2. Putative Last Glacial Maximum refugia and directions of postglacial *Alnus* migration (reproduced from Douda et al. 2014).

nization patterns in European bryophytes are unique among previously published work on other groups of plants and animals due to the substantial contribution of allochtonous migrants, with a substantial input of the Macaronesian islands that would, at first sight, not be expected.

1.1. Reconstructing biogeographic histories: an approximate bayesian computations in a coalescent context

Attempting at reconstructing species historical biogeography from the analysis of molecular data, which is the field of phylogeography (Avise et al., 1987), has long been based on the a posteriori interpretation of summary statistics of genetic structure and diversity and of the topologies of gene trees. Such a descriptive approach does not make it possible to statistically compare competing scenarios to identify the one(s) that best fit to the data, and the level of confidence of the best-fit scenario (Knowles and Maddison 2002). Model-based methods, particularly models

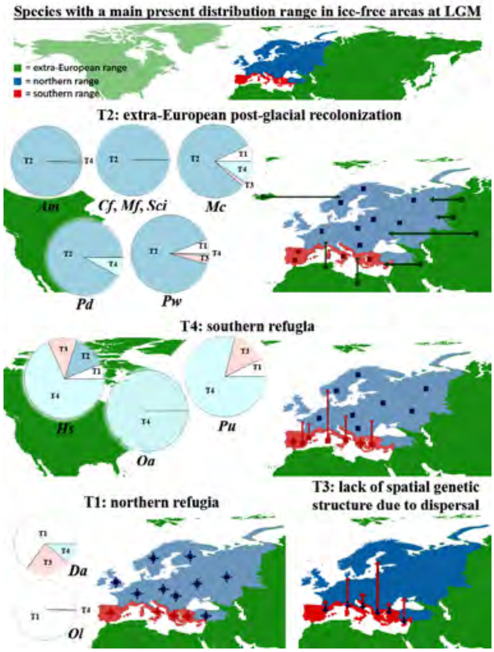

Fig. 3. Support for four competing historical scenarios of post-glacial recolonisation of bryophytes in Europe from coalescent simulations (see Box 1). Pie diagrams represent the posterior probabilities of each scenario. T1. northern micro-refugia. T2. extra-European recolonization. T3. 'panmictic' scenario, according to which high, ongoing migration rates have erased any historical signal in spatial patterns of genetic structure and diversity. T4. southern refugia (reproduced from Ledent et al. 2019).

that incorporate coalescent theory (Box 1), have therefore been increasingly developed during the last decade (Thomé and Carstens 2016).

In this framework, Patiño et al., (2015) and Ledent et al., (2019) attempted at reconstructing the post-glacial history of 11 and 12 bryophyte species whose distribution range is restricted to the North-East Atlantic region, encompassing the Macaronesian islands and the western fringe of Europe, and encompasses the entire European continent as well as large portions of the Holarctic, respectively. Coalescence simulations were performed in both cases to determine whether the post-glacial recolonization of Europe took place from (1) local refugia located in the southern (1a) or northern (1b) regions or (2) from allochtonous migrants.

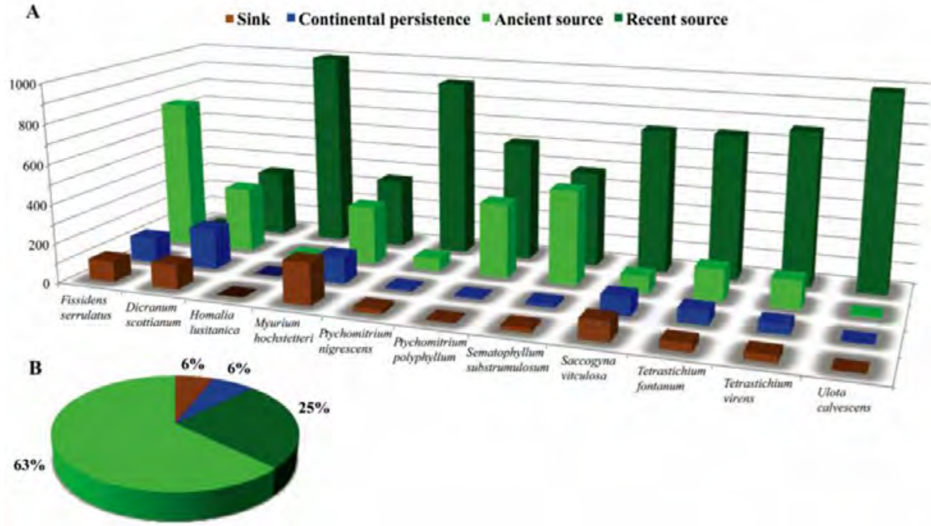

Fig. 4. Support for four competing historical scenarios of post-glacial recolonisation of NE Atlantic bryophyte species from coalescent simulations (see Box 1). Bars represent the posterior probabilities of each scenario (A) and the pie diagram (B) represents the average of best-supported simulations for the four competing scenarios across the 11 bryophyte species analyzed. In the 'sink' and 'continental persistence' scenarios, NE Atlantic island populations were historically founded from European migrants, but islands did not contribute to the post-glacial recolonization of Europe in the first case, whereas post-glacial migrations took place between Macaronesia and Europe in the second case. In the 'source' scenario, continental populations were founded *de novo* by migrants of insular origin. To determine the timing of continental colonization, the source scenario was further split into *recent* and *ancient source* scenarios, according to which the founding event of the continental populations took place either between the LGM and the first major ice advance during the Late Pleistocene (*recent source*) or before (*ancient source*) (modified from Patiño et al. 2015).

1.2. Post-glacial origin of the European Bryophyte Flora

The postglacial assembly of European and NE Atlantic bryophyte species involves a complex history from multiple sources, as different scenarios of postglacial recolonization clearly emerged as the best-fit scenario for different species (Figs. 3, 4). This complexity contrasts with the prevailing model in which species migrated northwards from southern refugia (Hewitt 2000; Petit et al., 2003). These findings thus challenge the taxonomic generality of the southern refugium scenario that has long been assumed to explain the distribution of genetic variation in bryophytes based on single-species analyses (Cronberg 2000; Grundmann et al., 2008).

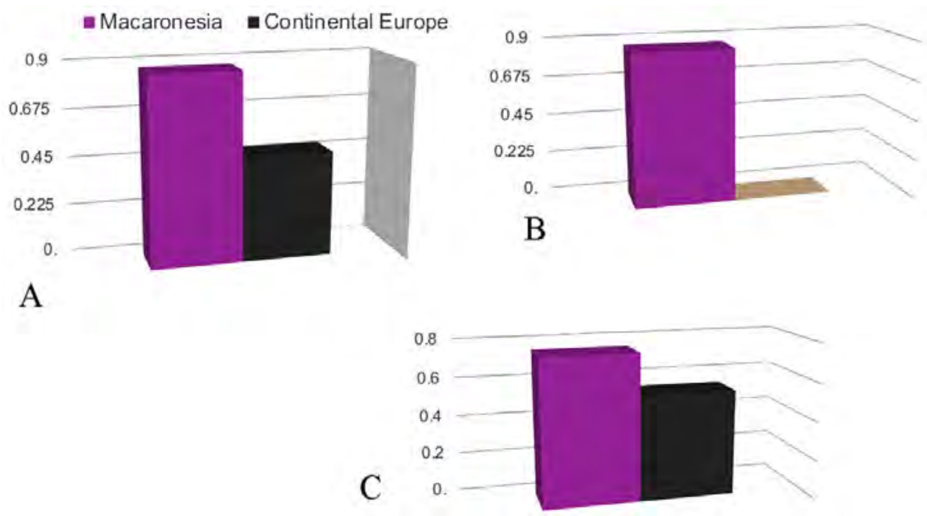

Fig. 5. Comparative levels of expected heterozygosity (He) at selected n and cpDNA loci of three typical NE Atlantic bryophyte species (A. *Sematophyllum substrumulosum*. B. *Ptychomitrium polyphyllum*. C. *Saccogyna viticulosa*) in Macaronesia and Europe (drawn from data in Patiño et al. 2015).

Among the investigated scenarios of post-glacial recolonization, the scenario of extra-European postglacial recolonization clearly emerged as dominant, being the best-fit for 7 out of the 12 species investigated in the European flora and all of the 11 investigated NE Atlantic species (Figs. 3, 4). Previous evidence in angiosperms demonstrated the postglacial recolonization of a remote Arctic archipelago from distant sources (Alsos et al., 2007). Individual instances of extra-European refugia (Hutsemékers et al., 2011; Laenen et al., 2011; Stenøien et al., 2011) were further evidenced during the postglacial history of European bryophytes. The substantial contribution of allochthonous migrants in the postglacial assembly of European bryophyte floras is, however, unparalleled in other plants and animals.

The substantial difference between the origin of migrants for the European and NE Atlantic floras is that post-glacial recolonization patterns involve the LGM persistence of in-situ small populations of species that pre-existed in Europe before the Ice Age and were reinforced by allochtonous populations for the former, but de novo colonization for the latter. Both floristic (Preston and Hill 1999, Vanderpoorten et al., 2007) and phylogenetic (Devos and Vanderpoorten 2009, Heinrichs et al., 2013) evidence points to a tropical origin for much of the North East Atlantic bryophyte flora. For example, examination of the phylogenetic position of *Myurium hochstetteri* or *Tetrastichium* spp. from the Moss Tree of Life (Cox et al., 2010) reveals that they are embedded within purely tropical clades. These observations sug-

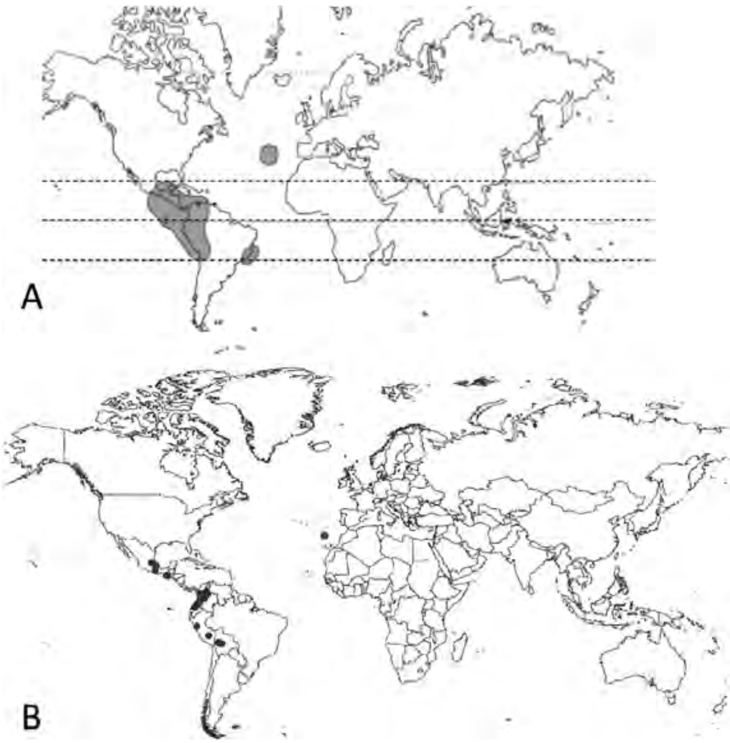

Fig. 6. Disjunct distribution between the Neotropics and Macaronesia.
A. *Plagiochila* sect. glaucescentes (reproduced from Feldberg et al., 2003).
B. *Syntrichia bogotensis* (Gallego et al. 2005).

gest that the Macaronesian archipelagos have played a key role as a stepping-stone for trans-continental migrants before they reach a new continental environment.

Patiño et al., (2015) estimated that the de novo colonization took place, for half of the investigated species, between 28,500 and 41,500 years ago. This extremely recent colonization explains why the strong founding effect associated with the colonization event is still remarkably reflected in the substantially higher genetic diversity observed in the source, island populations than in the sink, continental European populations (Fig. 5). Accordingly, genetic diversity in Atlantic bryophytes was substantially higher in island than in continental populations, contributing to mounting evidence that, contrary to theoretical expectations, island plant populations are not necessarily genetically depauperate (García-Verdugo et al., 2015).

The very short time frame for the continental colonization events underpins the notion that bryophytes may colonize new suitable habitats as soon as they become available, making them prime indicators of climate change. In this respect, the 5% of mosses and 8% of liverworts of the Macaronesian bryophyte flora that are endemic to the islands, as well as the 4% of mosses and 8% of liverworts that are disjunct between Macaronesian and tropical areas (Fig. 6), appear as candidates for migration towards western Europe and as models for investigating contemporary attempts of continental colonization. Altogether, these observations support growing evidence that oceanic islands are not necessarily the 'end of the colonization road' (Bellemain and Ricklefs 2008). Instead, oceanic islands increasingly appear as additional reservoirs for the assembly of continental floras, in full agreement with ecological predictions, according to which oceanic islands were larger and higher during glacial cycles (Fernández-Palacios et al., 2016; Weigelt et al., 2016), thereby offering ideal conditions for species to persist and diversify before colonizing continental areas.

One question, however, persists: why would Macaronesian islands represent a mandatory stepping stone for tropical species in transit towards Europe? Our hypothesis is that tropical species can need to pre-adapt under sub-tropical to warm temperate conditions in an environment before being able to colonize the temperate European biome. We currently aim at testing this hypothesis by comparing the transcriptome of tropical, Macaronesian and European populations, seeking for genes that appear as candidates for adaptation and investigating differences in the expression of those genes under contrasting climate conditions.

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3. AUTHORS' CONTRIBUTION

A.V. and J.P. designed the study. All the authors conducted the analyses. A.V. wrote the manuscript with the contribution of A.L. and J.P.

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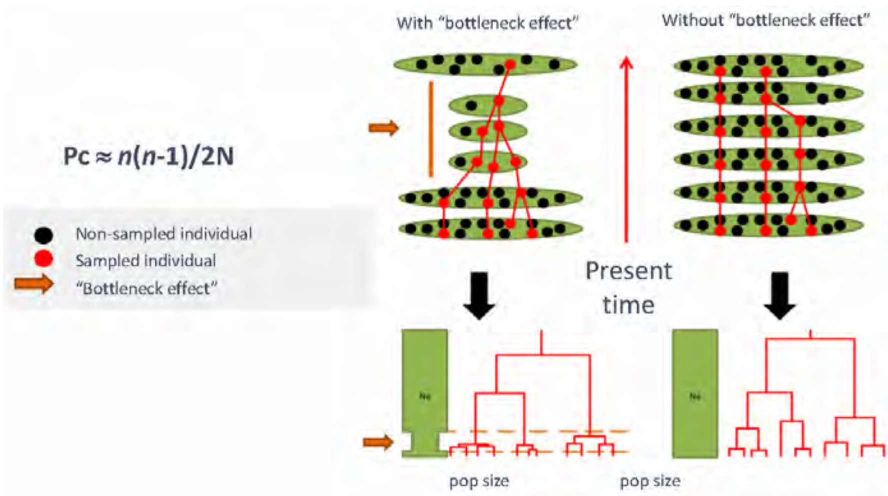

Fig. S1. Hypothetical gene genealogies for a standard coalescent model (right) and a bottleneck scenario (left).

BOX 1. IDENTIFYING BEST-FIT HISTORICAL BIOGEOGRAPHIC SCENARIOS FROM COALESCENT SIMULATIONS

The coalescent model, first described by Kingman (1982), aims at reconstructing the genealogy of all sampled gene copies of a given genetic marker in a population going backward in time until reaching the last common ancestral copy of all of them (see Hein et al. 2004; Marjoram and Joyce 2011; Nordborg 2001; and Wakeley 2008 for review). In a coalescent model, gene genealogies are controlled by demographic events, assuming that all gene copies have the same probability to be transferred to the next generation under a neutral model of molecular evolution in the absence of any selection.

The coalescent model defines the probability of coalescence Pc, which corresponds to the probability that two of the n sampled gene copies (red dots in Fig. S1) among the total number of gene copies (N) share a common ancestor at a given generation, and the coalescence time, which corresponds to the number of generations between two coalescence events. Pc can be roughly described as a function of the ratio between n and N. In a standard coalescent model, N remains constant through time. Due to the coalescence process, n decreases going back in time, so that Pc progressively decreases, leading to increasing coalescence times represented by increasingly long branches towards the root (Fig. S1 right). If the population undergoes a bottleneck back in time (arrow in Fig. S1), and N reaches lower values during the bottleneck, whereas n is not affected, resulting in an increasing of Pc during that period, shorter coalescence times. A 'bottleneck' coalescent tree is therefore represented by a series of shorter branches during the bottleneck event (Fig. S1 left).

When several populations are involved, the structured coalescent model aims at reconstructing the genealogy of all sampled gene copies across a meta-population divided into subpopulations (Wakeley, 2001). If we consider a meta-population subdivided into two subpopulations where at each generation, a small fraction of each subpopulation is made of migrants from the other subpopulation, the probability of coalescence between two sampled gene copies coming from the same subpopulations among all sampled gene copies of the meta-population (Pc(s)) and the probability of coalescence between two sampled gene copies coming from the two different subpopulations among all sampled gene copies of the meta-population (Pc(d)) can be established at a given generation. Pc(s) is the same than the probability of coalescence in a unique panmictic population, while Pc(d) depends on the migration rate between the two subpopulations and is likely to be much smaller than Pc(s). The time of coalescence, which corresponds to the time required to reach the common ancestor of two sampled gene copies among all sampled gene copies in a given population, can be established as well for two sampled gene copies coming from the same subpopulation and two sampled gene copies coming from the two different subpopulations. The expectation of those times (Et) follows these two relations:

$$Et(s) = n \text{ and+ } Et(d) = n + \frac{n-1}{M};$$

with Et(s), the expectation of the time of coalescence between two sampled gene copies coming from the same subpopulation; Et(d), the expectation of the time of coalescence between two sampled gene copies coming from the two different subpopulations; n, the sampling size of the meta-population; and M, the migration rate between the two subpopulations. Following these equations, if M is small, Et(d) is much larger than Et(s), so that the differentiation between the two subpopulations is high (Fig. S2); while if M is large, Et(d) is close to Et(s), so that the two subpopulations are similar (Fig. S2) (Hudson, 1991). In a meta-population context, the migration rate between subpopulations is thus another important parameter, along with the sampling size and the effective population size of subpopulations, that will impact the gene genealogies of any genetic marker simulated under the coalescent model. Because the demographic parameters N and M are unknown, they are sampled from user-defined prior probability distributions to generate millions of coalescence trees for each scenario.

In order to determine the most likely demographic scenario, DNA alignments of identical size as the observed ones are simulated for each scenario. Nucleotide substitution models are employed to predict mutations depending on branch length (Fig. S3).

Mutations are thus more likely to occur along long branches. In a 'bottleneck' coalescent simulation, mutations tend to accumulate along the long branches before the bottleneck event. As a result, the majority of these mutations occurs along the deepest branches and are shared among many individuals. In standard coalescent, in contrast, more mutations occur towards the shallowest branches. As a result, and for the same number of mutations, more alleles are expected under a standard coalescent than under a 'bottleneck' coalescent simulation (for example, 5 and 9

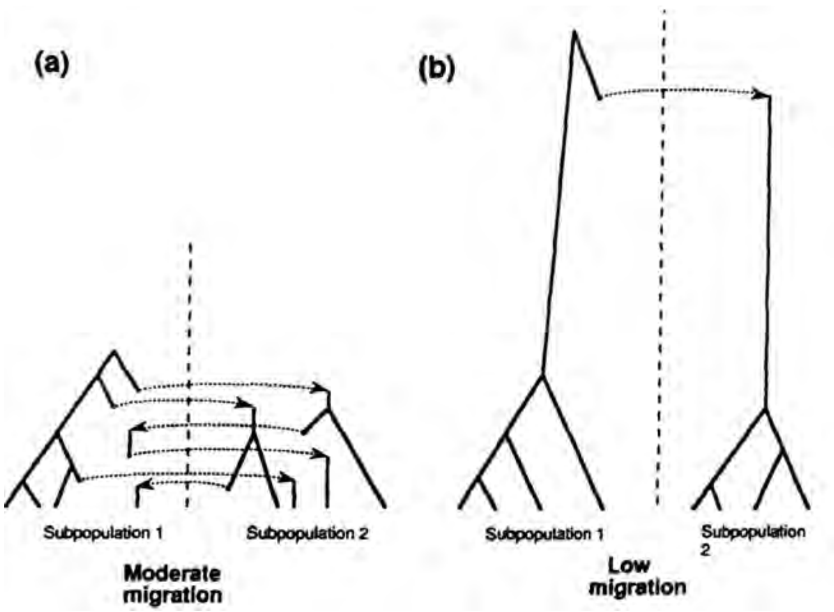

Figure S2: Example of a genealogy for a sampling size of 8, 4 from each of 2 subpopulations, when migration rate is moderately high (a) or involved a single dispersal event (b). Each migration event is indicated by a dotted line with an arrow that indicates the actual direction of movement of an individual migrant (Modified from Hudson 1991).

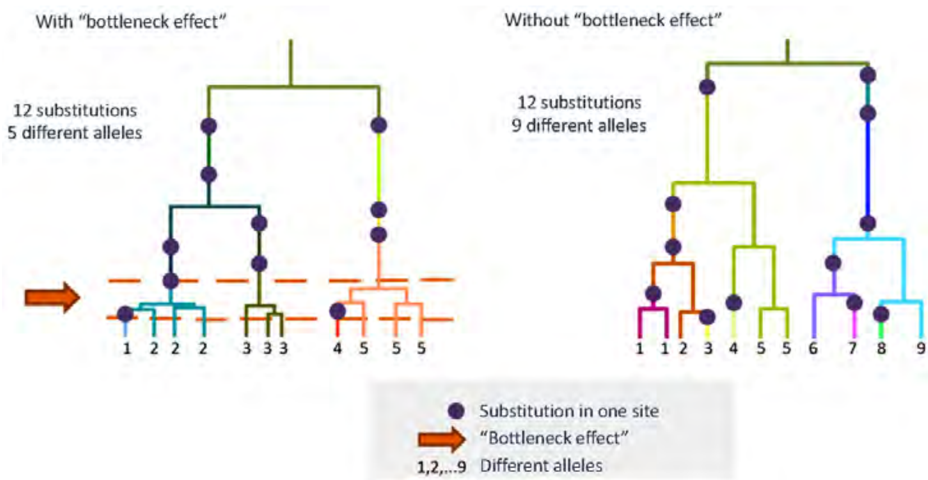

Fig. S3. Mutation mapping using DNA substitution models on the gene genealogies resulting from coalescent simulations under a standard (right) and bottleneck (left) coalescence process alleles for 12 mutations in the bottleneck and standard coalescent trees in Fig. S3). This process is repeated along each of the simulated gene genealogies to generate distributions of DNA sequences expected under different historical scenarios. Finally, summary statistics (e.g., number of alleles, Fst…) of these simulated DNA sequences are computed and a distance between the summary statistics of each simulation and of the observed data is computed. The scenario with the highest proportion of shortest distances is identified as the best-fit model.

EHRHARTA LONGIFLORA SM. AND *PENNISETUM SETACEUM* (FORSK.) CHIOV., TWO NEW ALIEN GRASSES FOR MADEIRA ISLAND (PORTUGAL)

Laura Cabral*, João Pedro Ferreira*, André Brazão*
Pedro Nascimento* & Miguel Menezes de Sequeira**

Abstract

The number of introduced, and possible introduced, taxa in the Madeira and Selvagens islands currently accounts for nearly 36% of the total flora of these archipelagos, including 53 Poaceae taxa (out of 141 Poaceae taxa), therefore constituting the family with the higher proportion of introduced taxa (38.4%). The genus *Ehrharta* Thunb. comprises about 35 species, with one species, *E. longiflora* Sm., recorded as introduced in Gran Canaria. The genus *Pennisetum* Rich. includes ca. 80 species of which a total of nine species are present in Macaronesia, with three: *P. clandestinum* Hochst. & Chiov., *P. purpureum* Schum. and *P. villosum* R. Br. ex Fresen, occurring in the Madeira archipelago. *Ehrharta longiflora* Sm. and *Pennisetum setaceum* (Forssk.) Chiov., are here recorded for the first time for the Madeira island, found in disturbed areas at low and medium altitudes. The finding of several mature and flowering/fructifying individuals of both species suggests a fully naturalized status. Naturalization, invasiveness and ecological impacts are discussed.

Keywords: Alien, *Eharharta longiflora*, grasses, Madeira, *Pennisetum setaceum*.

EHRHARTA LONGIFLORA SM. Y *PENNISETUM SETACEUM* (FORSK.) CHIOV., DOS NUEVAS GRAMÍNEAS EXÓTICAS PARA LA ISLA DE MADEIRA

Resumen

El número de taxones introducidos y posiblemente introducidos en los archipiélagos de Madeira y Salvajes supone aproximadamente un 36% de su flora total, incluyendo 53 taxa de Poáceas (sobre un total de 141 taxa de Poáceas), constituyendo, de esta manera, la familia botánica con mayor número de taxa introducidos (38.4%). El género *Ehrharta* Thunb. comprende unas 35 especies, con una especie, *E. longiflora* Sm., registrada como introducida en Gran Canaria. El género *Pennisetum* Rich. incluye cerca de 80 especies, de las cuales un total de nueve especies están presentes en Macaronesia, de las que tres (*P. clandestinum* Hochst. & Chiov., *P. purpureum* Schum. y *P. villosum* R. Br. ex Fresen), ocurren en el archipiélago de Madeira. *Ehrharta longiflora* Sm. y *Pennisetum setaceum* (Forssk.) Chiov. se citan en este trabajo por primera vez para la isla de Madeira, donde han sido encontradas en áreas perturbadas a bajas y medias altitudes. El hallazgo de varios individuos maduros en estado de flor/fruto de ambas especies sugiere que están totalmente naturalizadas. El trabajo discute la naturalización, la capacidad invasora y los impactos ecológicos generados por las mismas.

Palabras clave: especies exóticas, *Eharharta longiflora*, gramíneas, Madeira, *Pennisetum setaceum*.

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1. INTRODUCTION

The archipelagos of Madeira and Selvagens include 1204 taxa of vascular plants, including 401 introduced taxa and 29 as possible introduced (Jardim and Menezes de Sequeira 2008). In what concerns the grass family, more than one third correspond to alien taxa, i.e. 54 out of 141 (Jardim and Menezes de Sequeira 2008), corresponding to almost 12% of the total number of introduced vascular plant taxa.

Pennisetum Rich. is a cosmopolitan tropical genus that includes about 80 species native from Africa (Fish *et al.*, 2015). A total of 9 species of this genus are already reported in the Macaronesian archipelagos, 7 of them as aliens: *Pennisetum atrichum* Stapf ex Hubb. (Cape Verde), *Pennisetum clandestinum* Hochst. ex Chiov. and *Pennisetum villosum* R. Br. ex Fresen. (Azores, Madeira archipelago and Canary Islands), Pennisetum *purpureum* Schumach. (Canary Islands and Madeira), *Pennisetum setaceum* (Forssk.) Chiov., *Pennisetum thunbergii* Kunth and *Pennisetum glaucum* (L.) R. Br. (Canary Islands) (Sánchez-Pinto *et al.*, 2005; Jardim and Menezes de Sequeira 2008; Acebes Ginóves *et al.*, 2009; Silva *et al.*, 2010; Verloove 2013). There is also a reference to *Pennisetum macrourum* Trin. for the Canary Islands as cultivated and occurring spontaneous in one locality in Las Palmas (Reyes-Betancort *et al.*, 1999).

The segregation of the genera *Pennisetum* and *Cenchrus* L. has always been controversial. Diagnostic morphological characters being the degree of fusion of bristles and their characteristics, and the presence of pedicellate spikelets, however none of these characters can fully differentiate them (Chemisquy *et al.*, 2010). Although some authors still consider *Pennisetum* and *Cenchrus* as two separate genera (Fish *et al.*, 2015), recent molecular studies suggest otherwise (Donadío *et al.*, 2009). Chemisquy *et al.*, (2010), also based on molecular data, propose the inclusion of both *Odontelytrum* Hack. and *Pennisetum* in the genus *Cenchrus*.

Pennisetum clandestinum, was included in a separate genus –*Kikuyuochloa* H. Scholz (Scholz, 2006), but included in *Cenchrus* by other authors (Verloove 2012; Veldkamp 2014). The taxonomic and nomenclatural criteria adopted here follow Jardim and Menezes de Sequeira (2008). *Pennisetum setaceum* native distribution ranges from North Africa to the Middle East (Fish *et al.*, 2015). In Europe, it is

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presents as alien species in the south of the Iberian Peninsula, Canary archipelago and Sicily (Valdés and Scholz 2009). In Portugal, *P. setaceum* is naturalized in Alto Alentejo (Bejarano *et al*., 2011), Algarve (Marchante *et al*., 2014), and Estremadura (Gullón 2017).

Pennisetum setaceum was introduced as ornamental plant in the Canary Islands in the 40's (Saavedra and Alcántara 2017) and found naturalized in different locations in the north of Tenerife in 1969 (Hansen 1970). It is currently present in all the islands of the archipelago, prevailing below 500 m a.s.l., affecting the coastal xerophytic scrub and the endemic communities dominated by *Euphorbia canariensis* L. and *E. balsamifera* Aiton (González-Rodríguez *et al*., 2010). *P. setaceum* also outcompetes native grasses (e.g. *Hyparrhenia hirta* (L.) Stapf, *Aristida adscensionis* (L.), and affects the native rupicolous flora (Elorza *et al*., 2004; González-Rodríguez *et al*., 2010; Anonymous 2014).

Due to its fast growth and high capacity to adapt to different habitat conditions (Elorza *et al*., 2004), *P. setaceum* was recently included on the List of Invasive Species of Union Concern (EU 2017). Previously, this species was also included in the Spanish Catalogue of Invasive Alien Species, what entails in the "prohibition generic possession, transport, trafficking and trade of live or dead specimens, their remains or propagules, including foreign trade" (Anonymous 2014). Despite the conservation concerns, *P. setaceum* continues to be cultivated in many regions as ornamental plant (Gullón *et al*., 2017).

The genus *Ehrharta* Thunb. includes about 35 species, naturally distributed from South Africa to Ethiopia and Yemen (Fish *et al*., 2015). Four species of this genus: *E. calycina* Sm., *E. delicatula* Stapf, *E. erecta* Lam. and *E. longiflora* Sm., are present in Europe and North Africa (Morocco and Tunisia) as alien species (Valdés and Scholz 2009). *E. longiflora* was reported for Gran Canaria as naturalized for the first time by Kunkel (1978), as probably escape from cultivation, in a medium altitude (650 m a.s.l.), moist and shady habitat. In fact, *E. longiflora* is a palatable species for cattle, known to have a high leaf production (Fish *et al*., 2015).

Here we present the first record of *E. longiflora* and *P. setaceum* for the archipelago of Madeira. Naturalization, invasiveness and ecological impacts of both species are also discussed.

2. MATERIAL AND METHODS

Collected specimens where stored in the herbarium of the University of Madeira and identified using descriptions and keys published by Kellogg (2015) and Fish *et al*., (2015). During fieldwork, 2018 and 2019, collection sites were briefly characterized including: the approximate number of individuals of both species, the dominant plant taxa, exposure, slope and altitude (table 1). The distribution map (fig. 1) was produced using ArcGis online version E204CW. The two species occurred in disturbed areas highly exposed to the sun. Fully developed flowering and fructifying individuals of both species were found (figs. 2, 3, 4 and 5).

Figure 1. Distribution map of *Ehrharta longiflora* and *Pennisetum setaceum*.

TABLE 1. DATA ON *EHRHARTA LONGIFLORA* AND *PENNISETUM SETACEUM* MADEIRA POPULATIONS			
	Ehrharta longiflora	*Pennisetum setaceum*	
Localities	Ponta do Pargo	Santa Cruz	São Martinho
Date of field work	May/June 2018	August 2018/March 2019	March 2019
Number of individuals	<20	>1000	1
Dominant plant taxa	*P. clandestinum* with some individuals of *E. longiflora*	*P. setaceum* (in most of the cases) and shared with *P. clandestinum*, *Ageratina adenofora* and *Cardiospermum grandiflorum*	*Cenchrus ciliaris*, *Nicotiana glauca*, *Sinapidendron agustifolium*, *Parietaria* sp. and *Rumex* sp.
Altitude/ altitude range	568 m	50 to 200 m	15 m
Slope	30º	Between 0º and 90º	90º
Exposure	N	S and O	S
Description	Ruderal disturbed area along a roadside, next to agricultural land. High exposition to the sun, but with some humidity.	Ruderal disturbed area near a brook. Roads, houses and gardens nearby. High exposition to the sun.	Rocky cliff near the ocean, next to a pedestrian path. No gardens nearby.
Collector Number/ UMad	JF150	LC181	-

3. RESULTS

3.1. *Pennisetum setaceum* (Forsk.) Chiov

Two populations of *Pennisetum setaceum* are here reported: one in St. Cruz (NE of Funchal) and another in Funchal, both at low altitude (figure 1). Individuals of *Pennisetum setaceum* found in St. Cruz formed dense tuffs, mostly on terrains near

Figure 2. *Pennisetum setaceum* individuals forming dense tuffs on a terrain (St. Cruz).

Figure 3. *Pennisetum setaceum,* individuals in a basaltic walls (St. Cruz).

a road (figure 2), but also in cliffs and basaltic walls (figure 3) including on a margin of a small brook, corresponding to highly hemerobic areas close to roads, houses and gardens. *P. setaceum* was the dominant plant, although this dominance was shared, in some cases, with other alien plants such as *Pennisetum clandestinum*, *Ageratina adenophora* (Spreng.) R.M. King & H. Rob. and *Cardiospermum grandiflorum* Sw. *Cosentinia vellea* (Aiton)Tod. (table 1), a rare native fern in Madeira island, was found in chasmophytic invaded habitats.

One individual of *Pennisetum setaceum* was found on a cliff near the ocean in Funchal (São Martinho), next to a pedestrian path and with no gardens nearby, on a community dominated by *Cenchrus ciliaris* L., *Nicotiana glauca* R.C. Graham and *Sinapidendron angustifolium* (DC.) Lowe (table 1). After the first visit, the specimen was eventually removed, and no other individuals were found in the surrounding area.

PORTUGAL, MADEIRA, Santa Cruz; near "Rua da Ribeira" street; on a terrain near houses and gardens; 32º41'23.07"N; 16º47'44.39"W; alt. ca. 50 m a.s.l, 06-VII-2018, Laura Cabral, LC181, UMad s/n;

Based on Cope (1994), Veldkamp (2014) and Clayton (1980), we suggest a new key for the identification of *Pennisetum* species presents on Madeira archipelago.

Pennisetum Rich. key to the Madeira archipelago species:

1- Culms mat-forming, inflorescence reduced to a cluster of 2-4 subsessile spikelets enclosed in the uppermost sheath, with long protruding filaments and stigmas, involucral bristles soft .... *P. clandestinum*

1'- Culms erect to geniculate at base, inflorescence exerted, with many spikelets, involucral bristles stiff or softly villous 2

2- Dwarf plant up to 20(-40) cm, with a broadly cylindrical to sub-globose inflorescence, spikelets 7-14 mm, bristles softly villous .... *P. villosum*

2'- Plants generally larger, with a narrowly cylindrical inflorescence, spikelets 4.5-7 mm, bristles stiff 3

3- Plant up to 6 m (reed like), leaf blades flat 16-150 × 0.4-4 cm with spinulose margins, peduncle pilose below the inflorescence, involucre with one bristle distinctly longer than the others .... *P. purpureum*

3'- Plants up to 2 m, leaf blades involute 30-100 × 0.1-0.37 mm, with scaberulous margins, peduncle glabrous below the inflorescence, involucre with a few bristles distinctly longer than the others .... *P. setaceum*

3.2. *EHRHARTA LONGIFLORA* SM.

One population of *E. longiflora* was found in Calheta (Ponta do Pargo) (fig. 1) along a roadside close to agriculture fields occupying, so far, a very restricted area, dominated by *Pennisetum clandestinum* (table 1). This population included several mature individuals (figures 4 and 5) suggesting a fully, although localized, naturalization. In June, one month after the first visit, plants were subject to mowing, therefore no photographs of the naturalization site were taken.

PORTUGAL, MADEIRA, Calheta: Ponta do Pargo; along a roadside of "Estrada Regional 101", next to agricultural land; 32º48'6.04''N; 17º14'27.47''W; alt. ca. 568 m a.s.l, 12-V-2018, João Ferreira, JF150, UMad s/n.

Figure 4. *Ehrharta longiflora,* panicle.

Figure 5. *Ehrharta longiflora,* detail of panicle.

4. DISCUSSION

Pennisetum setaceum was probably introduced in Madeira island as ornamental plant, considering that this species is used in many parts of the world for this purpose and is often found in nurseries (Salinas *et al.*, 2011; Saavedra *et al.*, 2014; GIDS 2015; Gullón *et al.*, 2017). *P. setaceum* is a perennial C4 plant and, consequently, can withstand dryness and high temperatures, being widely used as garden plant (Rahlao *et al.*, 2010). Sometimes, it is also used for the stabilization of soil and cliffs (Salinas *et al.*, 2011). These characteristics, along with ecological adaptability, rapid growth and high seed production (100 seeds per plant), make it a species with high invasive potential (EPPO, 2012).

So far *Pennisetum setaceum* has a relatively small area of distribution on Madeira island, but according to Dana *et al.*, (2005) fruits are easily dispersed, by water, animals, people and even cars, being therefore highly probable that this alien grass will spread quickly to other areas. Salinas *et al.*, (2011) also refer that fruits are easily dispersed and to the fact that fruits remain viable in the soil for 6 years or more, being also capable of sprouting from root fragments.

Pennisetum setaceum prevails on arid and semi-arid open areas (Reyes-Betancort *et al.*, 1999; GISD 2015), and, therefore, Madeiran Mediterranean secondary grass communities (e.g. *Dactylo hylodes-Hyparrhenietum sinaicae*, *Cenchro ciliaris-Hyparrhenietum sinaicae* and *Bromo-Oryzopsion miliacei*, as defined by Capelo *et al.*, 2004) could be invaded by this grass. If this invasion occurs, it will possibly block successional processes, therefore affecting endemic communities such as *Euphorbietum piscatorie*. *P. setaceum* will also potentially affect chasmophytic plant communities (e.g. *Sedo nudi-Aeonietum glutinosi*).

Salinas *et al.*, (2011) describe the elimination by competition, of native and endemic species, but also changes in soil carbon sequestration, that further affect succession. In the Canary Islands *P. setaceum* can reach altitudes above 1000 m a.s.l (Reyes-Betancort *et al.*, 1999; Salinas *et al.*, 2011), but it seems to be limited to areas with an average annual rainfall of less than 1270 mm/m^2 (GISD 2015), not tolerating freezing temperatures (Devender 1997). These data suggest that the south coast and the east side of the island of Madeira are likely to be invaded and that most of the north coast and the mountain areas are less likely to be affected.

Due to the large amount of biomass accumulated, *P. setaceum* potentiates the risk of fires, which further increases its expansion (Salinas *et al.*, 2011).

Ehrharta longiflora was probably introduced for cattle feeding (see Fish *et al.* 2015), since it was found naturalized near agricultural fields. The dispersion of *E. longiflora* mainly occurs locally and is wind mediated, but fruits may also be dispersed by animals (Frey 2005). This species is already recorded as naturalized in several countries of North Africa and Europe, including Spain (Valdés and Scholz 2009) and being reported as invasive in Australia, New Zeeland and California (Frey 2005).

Ehrharta longiflora typically occurs in wet shady places (near rocks and shrubs), often near disturbed areas (e.g. gardens, roadsides), but is also found in hill slopes (Fish *et al.*, 2015). Apparently, the invasion of this and other *Ehrharta* spp. is facilitated by moisture. Besides that, these species can tolerate extensive annual summers in Mediterranean climates due to their deep-roots (Frey 2005).

In Madeira, *E. longiflora* possibly will prevail in areas of medium altitude, such as occurs in the Canary Islands (Kunkel 1978), but its invasiveness is hard to predict due to the scarcity of available information. Irrigated disturbed areas could be at higher risk of invasion, but this species may disperse to areas of high conservation value, possibly including laurisilva clearings and margins.

As in the islands of El Hierro, La Gomera, Fuerteventura and Lanzarote, where the introduction of *P. setaceum* was later (in the 1990s) (Garcia-Gallo *et al.*, 1999) and where control is still approachable, motorization of populations and quick intervention (eradication) seems to be the best strategies and should be applied for Madeira. According with Garcia-Gallo *et al.*, (1999) the removal of individuals, manually or using hoes, seems to be the most effective method of eradication of *P. setaceum* (and has been applied in many parts of the world). It is important to eliminate the floral parts first by carefully covering the inflorescences with plastic bags, and removing all root fragments and seeds that are present in the soil (Garcia-Gallo *et al.*, 1999). Chemical methods may be implemented in situations where the complete removal of individuals is not possible (walls, asphalt) using systemic herbicides such as hexazinone or similar products, since glyphosate appears to be ineffective (Anonymous 2014).

Although both taxa may become troublesome invasive, *Pennisetum setaceum* constitutes a clear threat to Madeira ecosystems. *P. setaceum* is still in an initial phase of invasion and plants should be eradicated urgently, and its use as ornamental prohibited.

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6. AUTHORS' CONTRIBUTION

Introduction: L.C., J.F.
Field work: L.C., J.F., P.N., A.B.
Methodologies: L.C., J.F., P.N., A.B., M.S.
Results and Discussion: L.C. J.F., P.N., A.B., M.S.
Review and edition of the final draft: M.S.

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TWO NEW ALIEN FERN TAXA FOR MADEIRA ISLAND (PORTUGAL)

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Abstract

The Madeira archipelago vascular flora includes 74 pteridophyte taxa. Of these, eight are exclusive endemics, eight are Macaronesian endemics, being the vast majority, 44, native and 14 referred as introduced taxa. The total number of alien vascular plant taxa is 401 (i.e. 33% of the total flora). The recent detection of several fully naturalized alien fern taxa is a process parallel to that observed in other groups of vascular plants. The occurrence of *Pteris nipponica* W.C. Shieh (syn. *Pteris cretica* L. var. *albolineata* Hooker) and *Goniophlebium subauriculatum* (Blume) C. Presl as new naturalized plants is recorded for the first time for the island of Madeira.

Keywords: Alien, Ferns, *Goniophlebium,* Madeira, *Pteris*, new records.

DOS NUEVOS TAXA EXÓTICOS DE HELECHOS PARA LA ISLA DE MADEIRA (PORTUGAL)

Resumen

La flora vascular del archipiélago de Madeira incluye 74 taxones de pteridofitas. De ellos, ocho son endemismos exclusivos, otros ocho endemismos macaronésicos, siendo la gran mayoría, unos 44, especies nativas y 14 más son consideradas exóticas. El número total de taxones de plantas vasculares exóticas es de 401, lo que supone aproximadamente el 33% del total de la flora. La reciente detección de muchas especies de helechos totalmente naturalizadas es paralela a la que ocurre con otros grupos de plantas vasculares. En este trabajo se registra por primera vez la presencia de *Pteris nipponica* W.C. Shieh (syn. *Pteris cretica* L. var. *albolineata* Hooker) y *Goniophlebium subauriculatum* (Blume) C. Presl como nuevas especies naturalizadas para la isla de Madeira.

Palabras clave: especies exóticas, helechos, *Goniophlebium*, Madeira, *Pteris*, nuevos registros.

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1. INTRODUCTION

Madeira island (32º 52' and 32º 38' N, 16º 39 'and 17º 15' W), located in the eastern Atlantic (978 km from mainland Portugal and 630 km from the west coast of Morocco), has an area of 741 km^2 and is the more recent island of the Madeiran archipelago (5.6 Ma, Jardim & Menezes de Sequeira, 2014). According to Jardim & Menezes de Sequeira (2008), a total of 74 pteridophyte taxa occur in the Madeira and Selvagens archipelagos, where 8 are exclusive endemics, 8 Macaronesian endemics, the majority (44) are native and 14 are introduced (according to Rumsey, pers. com., the actual numbers could be, 78 total taxa, 6 Madeiran endemics, and 9 Macaronesian endemics). Introduced vascular plant taxa contribute for 33% of 1204 taxa of vascular plants.

Comparing with the other Macaronesian archipelagos, Madeira has the higher number and diversity of native fern taxa, however, Azores has more fern taxa (83) than Madeira (Sánchez-Pinto *et al.*, 2005; Silva *et al.*, 2010; Jardim and Menezes de Sequeira 2008; Acebes Ginovés *et al.*, 2010). Several factors can explain this diversity namely, island age, topography heterogeneity (a related factor), bioclimate and ecological diversity and probably by the lack of recent volcanic eruptions in the island of Madeira (Capelo *et al.*, 2004; Ferrer-Castán and Vetaas 2005).

The recent identification of naturalized ornamental species corresponds to an increase in the total number of naturalized taxa that elucidates the current expansion of alien vascular plant taxa (e.g. Ferreira *et al.*, 2011, Pupo-Correia and Menezes de Sequeira 2014, Jardim and Menezes de Sequeira 2015).

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 145-153

2. MATERIAL AND METHODS

Fieldwork took place in 2016 and 2017, recorded data included slope, altitude, number of individuals and plant community description. Collected specimens were included in the University of Madeira Herbarium. Taxonomical identification followed Gibby and Paul (1994), Derrick *et al.* (1987), Page and Bennel (1984), Hovenkamp and Miyam (2005), Nauman (1993), Nogueira (1998), Rödl-Linder (1990), Walker (1993) and Xing *et al.* (2013).

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Figure 1. *Pteris nipponica* in Porto da Cruz.

3. RESULTS

New taxa:

Pteris nipponica W.C. Shieh (syn. *Pteris cretica* L. var. *albolineata* Hooker) (Pteridaceae) (figure 1).

Portugal, Madeira, Calheta. Across a *levada* close to a pathway at an altitude of ca. 139 m, 01-VIII-2017, Luís Berimbau, LB42, UMad s/n (sub Pteris cretica L.).

Pteris nipponica, known as white-striped Cretan brake fern, is widely distributed due to its use as ornamental species (GISD 2010; Stace 2010). Although referred as pantropical its native range is unclear (GISD 2010; GBIF 2017a). According to Nogueira (1998) it grows on shady rock walls or steep slopes. In the Madeiran archipelago four species of genus *Pteris* L. (Pteridaceae) were so far recognized, *P. vittata* L., *P. tremula* R. Br. and *P. multifida* Poir. as alien species and *Pteris incompleta* Cav. as native (Gibby & Paul 1994).

In Macaronesia, *Pteris nipponica*, referred as *P. cretica* var. *albolineata*, is found in the Azores (Sjögren 1973; Silva *et al.*, 2010) and the Canarian archipelago (Kunkel 1971). In both archipelagos, *Pteris nipponica* escaped from cultivation as an ornamental plant (Kunkel 1971; Sjögren 1973). *P. nipponica* is an appreciated ornamental plant much commercialized all over the world (Page & Bennel 1984; GBIF 2017b).

Pteris nipponica is easily distinguished from other Madeiran *Pteris* taxa by having irregular and variously pinnate fronds (Gibby & Paul 1994). *P. multifida* is close to *Pteris nipponica*, but has much narrower segments on fertile fronds. *Pteris nipponica* can also be distinguished from *P. multifida* for having pinnae of mature fronds not decurrent, with a broad, white, central stripe, the main character that separates *P. nipponica* from *P. multifida* (Nauman 1993).

Dichotomous key based on Gibby & Paul 1994 and Nauman 1993

1. Fronds pinnate, pinnae simple .... *Pteris vittata*

1'. Fronds more divided *2*

2. Pinnae irregularly divided into linear segments *3*

2'. Pinnae pinnatisect *4*

3. Pinnae of mature fronds decurrent to relatively broad-winged rachis in at least distal 1/2 of frond, pinnae all green .... *Pteris multifida*

3'. Pinnae of mature leaves not decurrent to relatively broad-winged rachis or only terminal pinna decurrent on rachis, pinnae with broad, white, central stripe .... *Pteris nipponica*

4. Pinna segments contiguous, narrowly triangular, sori on pinna segment margins longer on basiscopic side than on acroscopic side .... *Pteris incompleta*

4'. Pinna segments decurrent, lanceolate; sori on pinna segment margins equal in length .... *Pteris tremula*

The potential impacts of *P. nipponica* as alien species are largely unknown. In Madeira, this species appears to be a sub spontaneous naturalized plant but, possibly, it will become very frequent on walls and rocks everywhere in the island, as happened for *P. vittata* and *P. tremula* (Vieira 2002). One population of *P. nipponica*, fully naturalized in rocky habitats, was found in Calheta below 250 m, and it was also observed in Porto da Cruz (Machico, fig. 1). Populations included a reduced number of individuals, sometimes corresponding to one individual.

Goniophlebium subauriculatum (Blume) C. Presl, Tent. (Polypodiaceae) (figure 2).

Portugal, Madeira, Funchal, Madalenas, Caminho de Santo António. Rupícola, na margem de um caminho, alt. ca. 193 m. 01-VIII-2016. André Brazão, AB62. UMad s/n. (fig. 2).

Goniophlebium subauriculatum, commonly known as Caterpillar Fern, has a native range that includes NE India, SW China, Burma, Laos, Vietnam, throughout Malesia to Australia (Lindsay & Middleton 2012; Hassler, 2019). Although widely cultivated in many European gardens (Lowe 1856; Page & Bennel 1984) there is no reference to the naturalization of *G. subauriculatum* in Europe (Derrick *et al.*, 1987). Its occurrence as naturalized in Madeira Island constitutes the first naturalization

Figure 2. *Goniophlebium subauriculatum* in Funchal, Madalenas, Caminho de Santo António.

reference for Macaronesia and Europe both for genus and species (Jardim & Menezes de Sequeira 2008; Silva *et al*., 2010; Acebes Ginovés *et al*., 2009; Sánchez-Pinto *et al*., 2005; Acebes Ginovés *et al*., 2010).

Goniophlebium subauriculatum can be easily identified taking in account it's very long, up to 129 cm, slender simply-pinnate fronds and weeping habit. The fronds have a pendulous habit, are bright green in colour, lanceolate with pinnae long, narrow and lanceolate to acuminate in shape, articulated with the rachis, serrate on the edges, and sub-auriculate at the base. It has a pubescent rachis, a brown stipe articulated with a creeping and densely scaly rhizome. Another diagnostic character is its uniserial yellowish-brown sori, immersed in the frond, forming raised protuberances on its adaxial surface (Lowe 1856; Rödl-Linder 1990, F. Rumsey, pers. Com.).

Goniophlebium subauriculatum was found establishing fully naturalized, self-perpetuating populations, clearly dispersing away from the place of introduction. Observations support a successful sexual reproduction and therefore it may colonize new areas, mainly in rock or wall crevices, forming communities with other alien ferns such as *Pteris vittata* L. and *Nephrolepis cordifolia* (L.) C. Presl. It was found so far restricted to low altitudes (below 170 m a.s.l.) in Santo António (Funchal), forming small populations occurring both in shady or exposed rocky habitats. Naturalized individuals were found elsewhere in Funchal (S. Roque).

4. DISCUSSION

Both *Pteris nipponica* and *Goniophlebium subauriculatum* appear to form self-replacing populations by recruitment from spores or ramets capable of independent growth, without direct human intervention, and both should be considered as naturalized species (Pyšek *et al*., 2004). However, *P. nipponica* naturalization process is clearly more advanced than the one observed for *G. subauriculatum* mainly due to its distribution range with populations established far away from each other without cultivated specimens observed nearby, while *G. subauriculatum* has, so far, a restricted distribution.

The potential impacts of these alien species are unknown. However, other alien ferns are steadily expanding their ranges and are known to be displacing native species (in Madeira *Adiantum raddianum* C. Presl is a clear example), with catastrophic consequences for both the environment and human welfare (Robinson *et al*., 2010). More than 50% of the alien taxa correspond to plants originally introduced as ornamental garden plants and landscaping (Li *et al*., 2006). Both *Pteris nipponica* and *Goniophlebium subauriculatum* correspond to plants often used in gardens and nurseries (Lowe 1856; Page & Bennel 1984;GISD 2010), and their naturalization further stress's the urgent need for an efficient management and control of species used as ornamental plants.

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6. AUTHORS' CONTRIBUTION

Introduction: J.F.
Field work: J.F., L.C., P.N., A.B.
Methodologies: J.F., L.C., P.N., A.B., M.S.
Results and Discussion: J.F., L.C P.N., A.B., M.S.
Review and edition of the final draft: M.S., L.C.

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FALLEN FROM GRACE: FROM CHERISHED GARDEN DWELLERS TO INVASIVE SPECIES. THE STORY OF TWO GARDEN-ESCAPED VINES IN MADEIRA ISLAND

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Abstract

Cardiospermum grandiflorum Sw. and *Podranea ricasoliana* (Tanfani) Sprague were introduced after 1930s to be used for arbours and pergolas in gardens sited in warmer locations under 400 metres in south coast of Madeira Island. At the present they become very common and are densely growing over wastelands, stone walls, along stream banks, and over forsaken terraces. The historical expansion of these vines was evaluated using Repeat Landscape Photography Technique (RLPT). These species, which expanded in potential areas of *Mayteno umbellatae-Oleo maderensis sigmetum* (series of microforest of Madeiran oleaster tree) and *Semele androgynae-Apollonio barbujanae sigmetum* (series of laurel forest of barbusano–tree), spread into former agricultural lands and areas previously occupied by native vegetation or that could allow its regeneration. Although the evidence of being a threat to native vegetation recovery, no attempt has been made, up till now, to control them.

Keywords: Alien plant; Invasive plant; Fast-growing vine, Garden escapee, Repeat Landscape Photography Technique.

CAÍDAS EN DESGRACIA: DE APRECIADOS HABITANTES DEL JARDÍN A ESPECIES INVASORAS. LA HISTORIA DE DOS VIÑAS ESCAPADAS DEL JARDÍN EN LA ISLA DE MADEIRA

Resumen

Cardiospermum grandiflorum Sw. y *Podranea ricasoliana* (Tanfani) Sprague fueron introducidas después de 1930 para ser utilizadas en los jardines y pérgolas de las zonas inferiores a 400 m de altitud de la costa meridional de Madeira. En la actualidad son muy frecuentes, creciendo de forma muy densa sobre muros de piedra, cauces de aguas o terrazas de cultivos abandonados. Se ha evaluado la expansión histórica de estas enredaderas utilizando la técnica de la fotografía paisajística repetida. Estas especies, que se expanden en el área potencial del *Mayteno umbellatae-Oleo maderensis sigmetum* (series de microbosques del acebuche de Madeira) y en el del *Semele androgynae-Apollonio barbujanae sigmetum* (series de laurisilva de barbusano), se expanden en antiguas áreas agrícolas y en áreas previamente ocupadas por vegetación nativa o que podrían propiciar su regeneración. Pese a que es evidente que son una amenaza para la recuperación de la vegetación nativa, hasta el momento actual no se han desarrollado planes para su control.

Palabras clave: plantas exóticas, plantas invasoras, enredaderas de crecimiento rápido, escape de jardines, técnicas de repetición de fotografía paisajística.

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1. INTRODUCTION

Cardiospermum grandiflorum Sw. and *Podranea ricasoliana* (Tanfani) Sprague were introduced in the first half of the twentieth century to be used for arbours and pergolas in gardens located in warmer locations under 400 metres in south coast of Madeira Island (Vieira 2002). *C. grandiflorum*, is a species native to tropical America, extending from the Southern Mexico to the South American territories and tropical Africa, although there is certain degree of uncertainty about the latter status (Chapman et al. 2017). In Madeira Island it was been pointed out by Grabham (1934) as cultivated plant, identified then as the very similar and closely related species *C. halicacabum* L. (Vieira 2002), and considered as naturalised in late 1960s (Hansen 1968). It was also introduced in early 20th century in many other regions as South Africa, Australia, some regions in the Mediterranean area and Canary Islands, where the species also become established and considered invasive (Chapman et al. 2017) being currently included in the list of 100 most invasive species in Macaronesia (Silva et al. 2008) and one of 100 most invasive species of the world (Global Invasive Species Database 2019). *Podranea ricasoliana*, a popular garden plant across de world, is native of Tropical East and South Africa (Bidgood et al. 2006). The species was probably introduced in Madeira after late 1940s, since it was not referred by Grabham (1942). Being an extremely vigorous climber and drought resistant in addition to gardening activities it was also used to support soil and banks, mainly in Funchal and surroundings (Vieira 2002) becoming naturalised in mid-1970s (Vieira 1974). Although not included in the lists of the most invasive plants, mentioned above, this species is considered an invasive garden-escape in areas where it was also introduced as ornamental plant as Australia, New Zealand (Malan and Notten 2002) and Hawaii (HEAR 2013).

Invasive alien species are a menace to native ecosystems and biodiversity having significant ecological and socioeconomic impacts throughout the world and particularly on islands, due to their vulnerability to the effects of non-native species. Attempts to eradicate or control them have high uncertainty and barriers to their success are in general related to human unwillingness rather than scientific and technologic constraints (Reaser et al. 2007).

The aim of this paper was to assess the historical expansion of these two invasive vines gathering information of the dynamics of these two species, and, the-

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refore, contribute for future studies that intend to perceive the pattern of these two species for better control strategies.

2. METHODS

The historical evolution was evaluated using 200 historic (1875-1950) and recent (2006-2013) photographs produced with RLPT (Repeat Landscape Photography Technique), ranging from 56 to 131 years of time interval assessed. The historical photographs were digitised into 8-bit grey-scale images in TIFF format. The replicated photographs of the historical photographs [large format, high resolution (TIFF quality)] were acquired from the same point and camera axis orientation, with a Cannon EOS 60D camera equipped with EF-S 17-85 IS VS11 lens. After finding the general location of the landscape photographed, placing the camera in the exact position and height above ground was achieved by using a coarse "cross-hair" grid drawn on a printed copy to compare the view and to line up features, on the right and on the left, and in the foreground and background (Malde 1973). Image orientation was established by the intersection of the lines that cross the fiducial marks [a simplification of the aerial photography method to identify the principal point (Lillesand and Kiefer 1994). For further detail see Pupo-Correia et al. (2014). Because this research aimed to quantitatively evaluate changes, images within each photo-pair were co-referenced to each other and were analysed by remote sensing and geographic information system technologies (ArcGIS 9.3). It was used a Georeferencing tool to place landscape features in same coordinates in both images, with at least four control points (root mean square error ≤ 0.05 pixel). Same software was used to classify landscape features by creating vector files, with polygons representing distinct land coverage types (supervised classification). To quantify the alteration, shapefiles of the sampled areas of each photo-pair were intersected (Intersect tool). This new shapefile enabled to get information about features or portions of features that overlap, to calculate geometric relationships between them (Calculate Geometry tool) and to create a contingency table for statistical changes analysis. The area values that were calculated meant to quantify the changes in image cover and not to measure the real surface area.

3. RESULTS AND DISCUSSION

Ornamental plants introduced in domestic gardens, as it is worldwide recognised, make up majority of the most successful invasive species. Plant traits making them suitable for gardening, plus careless environmental practices in management of domestic gardens are important circumstances in the invasion success of alien species (Dehnen-Schmutz et al. 2007; Pyšek and Richardson 2007; Dawson et al. 2008; Guo et al. 2019), as it is the case of these two species (Malan and Notten 2002; Chapman et al. 2017).

Figure 1. (a) Landscape zoom of historical and repeated landscape photographs taken in Ribeira Brava in early twenty century (by unknown photographer, ARM) and in 2010 (AP,MS), highlighted polygons correspond to areas were *Cardiospermum grandiflorum* Sw. was seen in current landscape; (b) A 'curtain infestation' of *C. grandiflorum* over a stream bank. Funchal, south coast, 2015 (AP).

Neither of the two species were identified in historical landscape, in accordance with the information about the time they were given as naturalised plants. *C. grandiflorum* and *P. ricasoliana* were the vines more often seen in photographed landscape (40/200, compared to 7/200 photographs showing all other naturalised vines). In the present landscape, they were more often detected in photographs of southern coastal regions (32, compared to 8 in the north coast) as the distribution referred by Short (1994) and Vieira (2002) i.e., mainly south coast up to 400 metres (a.s.l.). Results have shown that although the *C. grandiflorum* invaded different environments, it greatly overran lands that were no longer farmed, especially in southern areas (fig. 1a, 3), forming dense patches of balloon-vines growing together (fig. 1b). *P. ricasoliana* have shown major predominance in Funchal urban area where it grows profusely over the steep rocky banks of main streams crossing the valley (fig. 2b). On the north coast they were also seen rambling over abandoned terraces and native vegetation.

Both species were seen spreading over potential areas of Madeiran oleaster tree and barbusano-tree vegetation series (fig. 2a, 3): These areas have been occupied since the early days of colonial settlement by agriculture and construction and plant communities of the seral stages are rare, solely occurring in small isolated patches (Menezes de Sequeira et al. 2007). Due to the ability of vines to compete by stifling and killing non-climbing plants, the presence of these species in areas where native vegetation recovered, or could allow its regeneration, can block native vege-

Figure 2. (a) Landscape zoom of historical and repeated landscape photographs taken in Porto da Cruz in early twenty century (by unknown photographer, ARM) and in 2012 (AP,MS), highlighted polygon correspond to the area were *Podranea ricasoliana* (Tanfani) Sprague was seen in current landscape; (b) *P. ricasoliana* which densely covers a cliff preventing any other vegetation growth. Funchal, 2015 (AP).

tation development for decades or completely change the direction of native forest succession (Paul and Yavitt 2010). In addition, *C. grandiflorum* is included in several lists of most invasive species, in Macaronesia as worldwide (Silva et al. 2008; Chapman et al. 2017), and *P. ricasoliana* was indicated as invasive species (HEAR 2013) as well. Although these two species were not assessed as dominant/moderate invaders in a comparison of plant invasions in 30 archipelagos all over the world (Kueffer et al. 2010), same study have shown that alien plants with invasive behavior in other islands are much more likely to become invasive than any other naturalised species. For these reasons, these two taxa must be taken as a major threat to native vegetation and biological diversity and ought be submitted to eradication and control, as it has been carried out in some other places where this smothering species it is also a hard-hitting invasive plant (Foxcroft et al. 2008; Foxcroft et al. 2013). However, up till now, no attempt was made to control them in Madeira Island (Silva et al. 2008).

4. CONCLUSION

C. grandiflorum and *P. ricasoliana* expanded in potential areas of *Mayteno umbellatae-Oleo maderensis sigmetum* and *Semele androgynae-Apollonio barbujanae sigmetum*, spreading from gardens into former agricultural lands and barren areas,

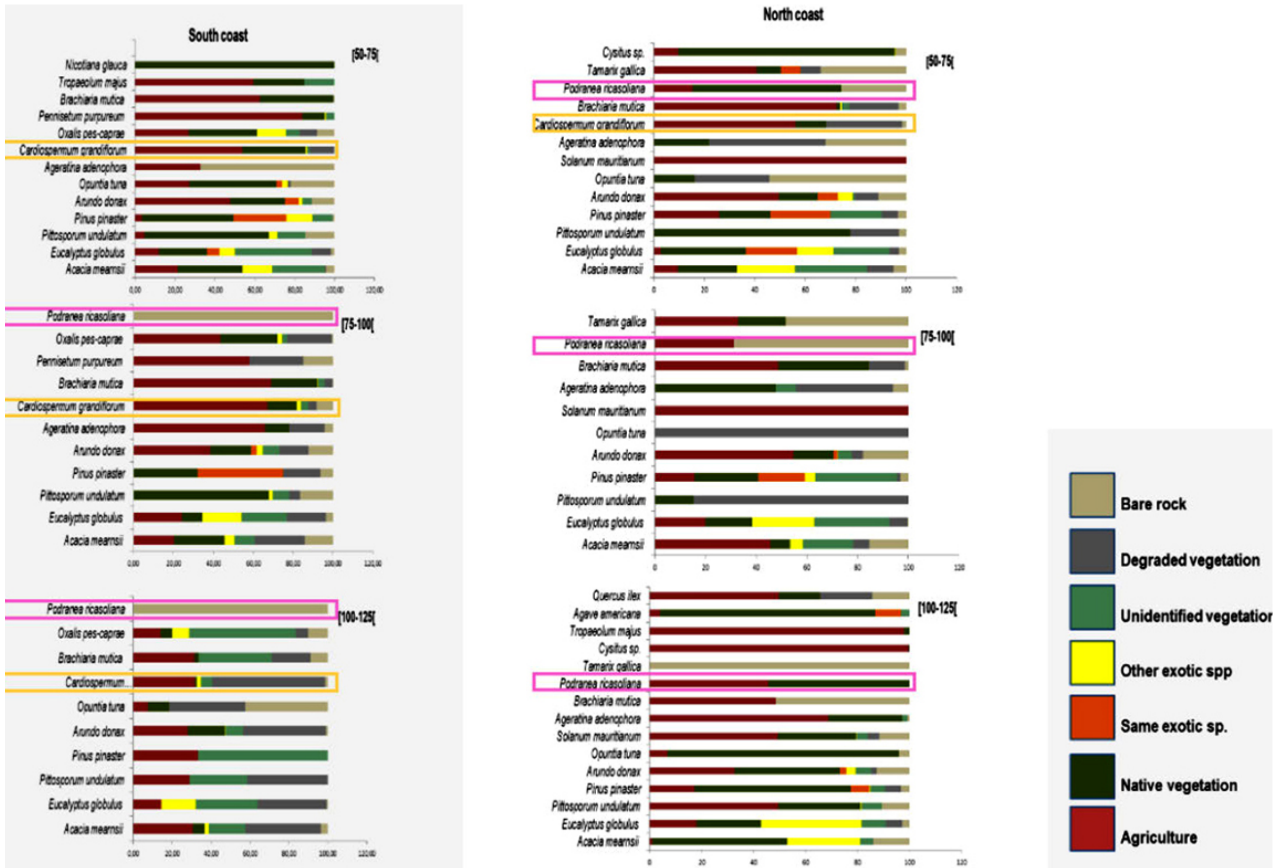

Figure 3. Percentage of past landscape features where *C. grandiflorum* (surrounded by orange line) and *P. ricasoliana* (surrounded by pink line) spread over.

preventing native vegetation regeneration and smothering the one that has recovered. Since these invasive alien species can cause serious damage to biological diversity it is the utmost interest to develop measures to control them, as it has been carried out in some other places, where these smothering species are also hard-hitting invasive plants.

5. AUTHOR'S CONTRIBUTION

A. Pupo-Correia and M. Menezes de Sequeira conceived the idea and carried out the field work; J. Aranha proposed and verified the analytical methods. A. Pupo-Correia performed the analysis, drafted the manuscript and designed the figures. All authors discussed the results and contributed to the final manuscript.

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MACARONESIAN BOTANY AND THE *ENDEAVOUR* VOYAGE: THE COLLECTIONS AND RECORDS OF JOSEPH BANKS AND DANIEL SOLANDER FROM MADEIRA

Arnoldo Santos-Guerra*, Mark A. Carine**
& Javier Francisco-Ortega***

Abstract

The efforts of Joseph Banks and Daniel Solander to document the vascular plant, bryophyte, fungal, algal, and lichen flora of Madeira during the first circumnavigation of James Cook on Her Majesty's Bark *Endeavour* (1768-1771) are documented. Banks's journal (at the State Library of New South Wales, Australia) provides accounts pertinent to the species observed in this visit and also includes a list of 330 entries that were recorded during their stay in this Portuguese island. Where possible, the species documented in this list were matched with corresponding herbarium collections held in the herbarium of the Natural History Museum, London, where the herbarium of Joseph Banks is now housed. Comparisons were made with two documents also housed in this Museum, namely: Solander's unpublished flora of Madeira (*Primitiae Florae Maderensis, sive catalogus Plantarum in Insula Madera*) and an inventory of specimens that were collected and stored inside drying books during the expedition.

Keywords: botanical history, Atlantic islands, plant taxonomy, botanical exploration, Enlightenment.

BOTÁNICA MACARONÉSICA Y EL VIAJE DEL *ENDEAVOUR*: LAS COLECCIONES Y OBSERVACIONES DE JOSEPH BANKS Y DANIEL SOLANDER DE MADEIRA

Resumen

Se examinaron, en el herbario del Museo de Historia Natural de Londres, las recolecciones de plantas vasculares, briofitas, hongos, algas y líquenes realizadas por sir Joseph Banks y Daniel Solander en Madeira durante el primer viaje de James Cook alrededor del mundo (1768-1771). El diario de Banks (en la Biblioteca Estatal de Nueva Gales del Sur, Australia) tiene detalles sobre las especies observadas en esta expedición y también tiene un registro de 330 entradas con las especies que se observaron durante su estadía en dicha isla portuguesa. Las especies de esta lista se estudiaron y cotejaron con los ejemplares de herbario. Se hicieron comparaciones de este registro con datos de dos documentos que también se encuentran en este museo, a saber: la flora inédita que Solander preparó para Madeira (*Primitiae Florae Maderensis, sive catalogus Plantarum en Insula Madera*) y el inventario hecho por Banks y Solander de los especímenes recolectados durante la expedición que fueron preservados dentro de los libros que se usaron para secar plantas durante el viaje.

Palabras clave: historia de la botánica, islas atlánticas, taxonomía vegetal, exploración botánica, la Ilustración.

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I. INTRODUCTION

The three voyages of James Cook (1768-1779) were among the most important eighteenth-century expeditions of discovery. Collectively, his trips were the first to visit all of the Macaronesian archipelagos with the exception of the Selvagen Islands (Francisco-Ortega et al. 2015). The first voyage called at Madeira between September 12 and 18, 1768. Two of the most important figures in the history of botany, Joseph (later Sir Joseph) Banks (1743-1820) from Britain and Daniel Solander (1733-1782) from Sweden were onboard. As part of this issue of *Scientia Insularum* devoted to the *FloraMac2018* international meeting, Prof. Jordan Goodman has focused on the main historical aspects of the visit to Madeira made by these two well-known botanists (Goodman 2020); our contribution will provide a review of the plant collections and records that they made on this island. In a subsequent study we will review the influence and impact that the contributions of Banks and Solander had on botanists such as Christen Smith (1785-1816), Leopold Von Buch (1774-1853) or Richard T. Lowe (1802-1874) who studied the Macaronesian flora, particularly in the 19th century (Santos-Guerra in prep.).

Sydney Parkinson (1710?-1771) also joined the expedition as the illustrator responsible for botany and natural history more generally with his fellow Scot Alexander Buchan (d. 1769) responsible for landscapes and figures. Both died during the voyage. On Madeira, Parkinson made drawings of Madeiran plants, 16 of which were finished as watercolors (fig. 1). The reader can find further details of these illustrations in Francisco-Ortega et al. (2015). Eleven of Parkinson's watercolors from Madeira resulted in engravings that were eventually published in the 20th century as part of the work known as *Banks's Florilegium* (Banks et al. 1985), long after they were first painted.

The herbarium collections made by Banks and Solander in Madeira are among the earliest from Macaronesia but were preceded by others made by pioneer plant collectors such as Scottish surgeon James Cuninghame (c. 1655-1709) in La Palma in 1678-79 (Santos-Guerra et al. 2012); and the English physician and collector Sir Hans Sloane (1660-1753) in Madeira in 1687 (Menezes de Sequeira et al. 2010). Other early naturalists who contributed to the study of the Macaronesian flora included Louis Feuilleé (1660-1732), who in 1724, during his second visit to the Canaries (La Gomera, El Hierro, La Palma, and Tenerife), made the first known drawings of Macaronesian plants in their habitats (Puig-Samper and Pelayo 1997).

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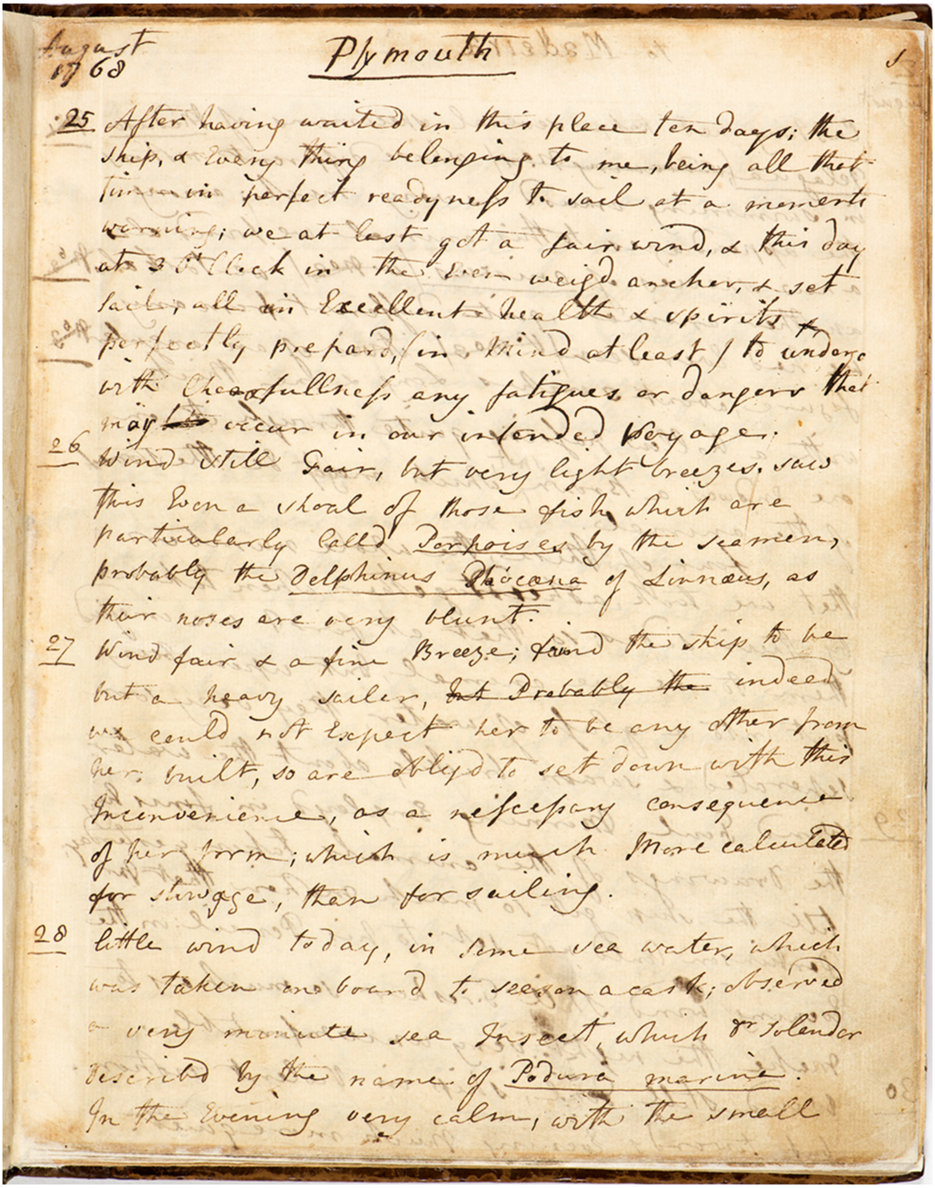
Figure 1. Watercolor of *Eugenia uniflora* made by Sydney Parkinson in 1768, based of material recorded in Madeira during the *Endeavour* voyage. Image copyright of the Natural History Museum of London.

In this paper we present a study based on the manuscript that includes the list of Madeiran plants that Banks recorded in his two-volume expedition journal housed at the State Library of New South Wales, Australia [available online in https://www.sl.nsw.gov.au/banks/section-02/series-03/03-01-volume-1-joseph-



August 1768 Plymouth 1

25 After having waited in this place ten days, the ship, & every thing belonging to me, being all that time in perfect readyness to sail at a moments warning; we at last got a fair wind, & this day at 3 O'Clock in the Even weigd anchor, & set sail, all in Excellent health & spirits & perfectly prepard (in Mind at least) to undergo with Chearfullness any fatigues or dangers that may occur in our intended voyage.

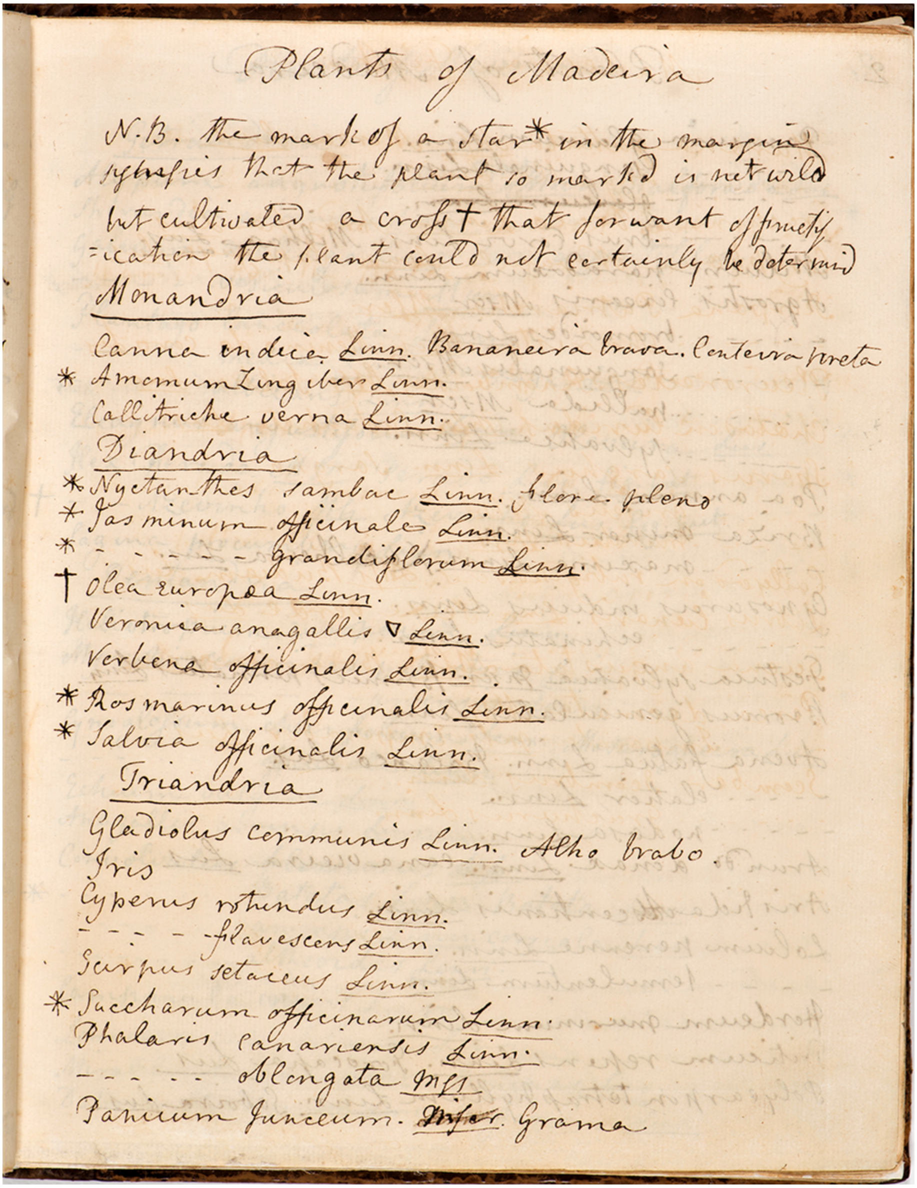
26 Wind still fair, but very light breezes, saw this Even a shoal of those fish which are particularly calld Porpoises by the seamen, probably the Delphinus Phocaena of Linnaeus, as their noses are very blunt.

27 Wind fair & a fine Breeze; found the ship to be but a heavy sailer, ~~but probably the~~ indeed we could not expect her to be any other from her built, so are obligd to set down with this Inconvenience, as a necessary consequence of her form; which is much more calculated for stowage, than for sailing.

28 little wind today, in some sea water, which was taken on board to season a cask; observd a very minute sea Insect, which Dr Solander describd by the name of Podura marina. In the Evening very calm, with the small

Figure 2. First page of the journal of Joseph Banks, written during the first circumnavigation voyage of James Cook. Image copyright of the State Library of New South Wales, Australia.

banks-endeavour; figs. 2-3]. The list is part of Volume 1 of the journal and is inserted after folio 33. It comprises 13 numbered folios and has a total of 330 plant entries. Banks's journal, including the list of specimens from Madeira, was transcribed by



Plants of Madeira

N.B. the mark of a star* in the margin signifies that the plant so marked is not wild but cultivated a cross † that for want of fructification the plant could not certainly be determind

Monandria

Canna indica Linn. Bananeira brava. Conteira preta
* Amomum Zingiber Linn.
Callitriche verna Linn.

Diandria

* Nyctanthes sambac Linn. flore pleno
* Jasminum officinale Linn.
* - - - - grandiflorum Linn.
† Olea europaea Linn.
Veronica anagallis ∇ Linn.
Verbena officinalis Linn.
* Rosmarinus officinalis Linn.
* Salvia officinalis Linn.

Triandria

Gladiolus communis Linn. Alho brabo.
Iris
Cyperus rotundus Linn.
- - - flavescens Linn.
Scirpus setaceus Linn.
* Saccharum officinarum Linn.
Phalaris canariensis Linn.
- - - oblongata MSS
Panicum junceum. ~~MSS~~ Grama

Figure 3. First page of list of plants recorded in Madeira found in the journal of Joseph Banks. Image copyright of the State Library of New South Wales, Australia.

Beaglehole (1962b: 281-289); however, the transcription of the list included some errors. In our contribution we provide a literal transcription of this part of Banks's journal (see full interpreted list further below).

One of our main aims in this paper is to provide an updated taxonomic identification of the vascular and non-vascular plants and lichens that Banks listed for Madeira in this manuscript. We matched these entries with the herbarium collections that Banks and Solander made in Madeira housed in the Natural History Museum, London (BM). As a working taxonomy we have followed Press and Short (1994), Jardim and Menezes de Sequeira (2008), and Menezes de Sequeira et al. (2012).

II. BOTANICAL RECORDS IN BANKS'S JOURNAL

The list of Madeiran plants found in Banks's journal comprises 330 entries (324 taxa) that include 303 spermatophytes, twelve ferns, two mosses, two liverworts, one alga, and four lichens (see full interpreted list further below). All of the identified taxa have a single entry in this list with the exception of six that have two entries each, namely: *Convolvulus althaeoides* (entries 65, 68), *Cynoglossum creticum* (entries 61, 62), *Malva sylvestris* (entries 203, 204), *Ramalina calicaris* (entries 321, 325), *Olea maderensis* (entries 7, 54), and *Salix x rubens* (entries 287, 288). Approximately half of the entries recorded in this list correspond to cultivated (72 entries) or introduced taxa (67 entries). Of the remaining entries, 18 are Macaronesian endemics, 19 are Madeiran endemics, and 153 are non-endemic natives.

For 94 of the entries (93 taxa), local Portuguese common names are indicated (in many cases abbreviated as "Lus."). The abbreviations "Mscr." or "Mss." were used to refer to putative new taxa, 37 in total, recognized by Banks and Solander. Since they were used only in a manuscript, they are unpublished designations although many were subsequently published by other botanists. Banks's manuscript also states (as "fig. pict.") those taxa which were illustrated by Sydney Parkinson. Two symbols were used to further identify the recorded material: asterisks (*) refer to those species that Banks and Solander regarded as cultivated or introduced (although some entries for cultivated plants are not marked) and plus symbols (+) denote entries for which they were uncertain of their taxonomic identification.

During their short stay in Madeira, Banks and Solander only collected "in the neighborhood of the town [Funchal], never going above three miles from it" (September 13 record in Banks's journal). However, they were able to make an extremely rich herbarium collection including species such as *Juniperus oxycedrus* (= *J. cedrus* subsp. *maderensis*), *Taxus baccata* and *Vaccinium padifolium,* all of which are from inland parts of the island and do not occur naturally around Funchal. It is likely that they received specimens from collaborators during this visit. Thomas Heberden (1703-1769), a British physician and botanist who lived and died in Madeira (Heberden 1990) was instrumental in the discovery of botanical novelties by Banks and Solander in Madeira. Regarding the interactions that Banks and Solander had with Heberden during their stay in Madeira, from Rio de Janeiro Solander wrote a letter to the British naturalist John Ellis (c. 1710-1776) on 1 December 1768 (Beaglehole 1962b: 309-310) that stated:

> If any of your friends go to Madeira, advise them to get recommendations to Dr Heberden; he has more influence there than the governor. He is just such a philosopher as my friend, and very communicative. His many instruments, mathematical and optical, have procured him the name of *il Doctore Docto*.

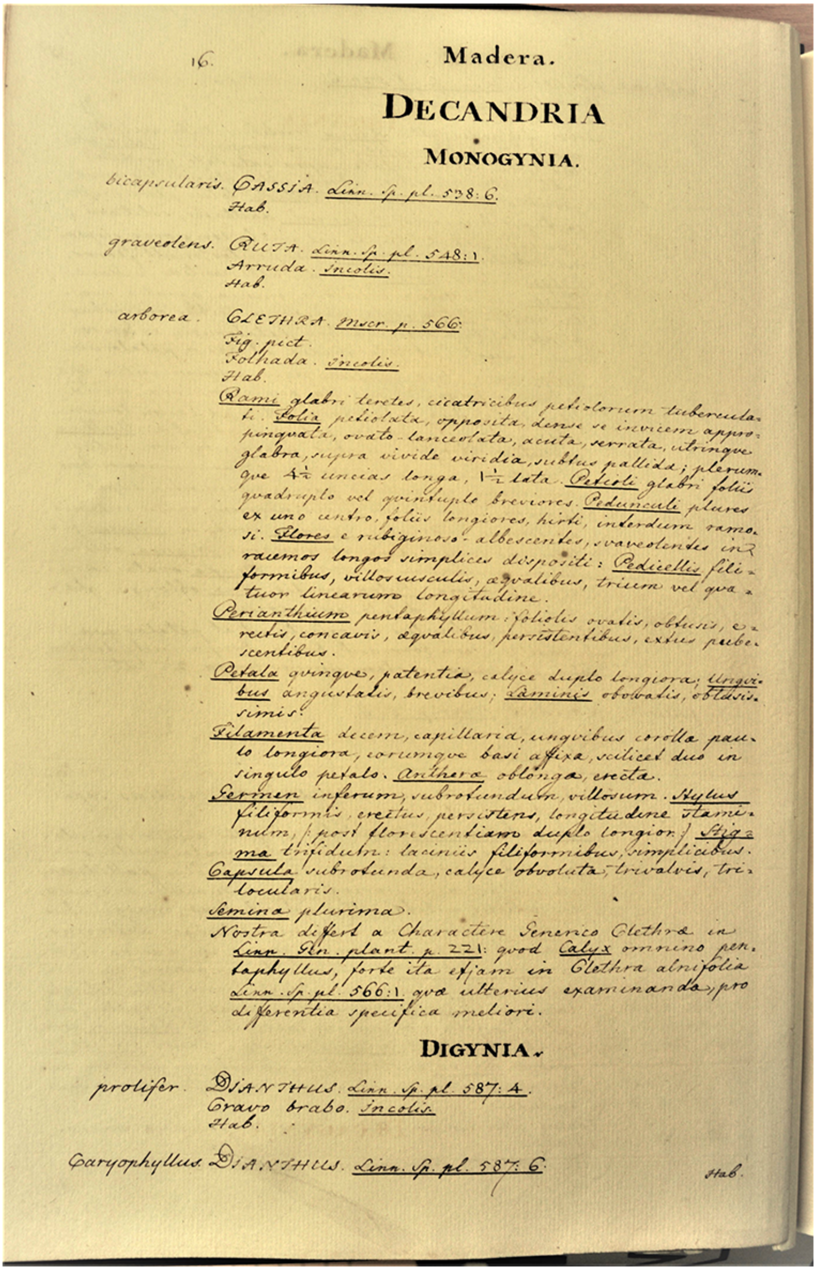
Heberden had earlier lived in the Canary Islands (Gran Canaria and Tenerife) between the 1730s and 1747. He wrote one article about Mount Teide, Tenerife (Heberden 1752) but in 1740 he faced the Inquisition and was sent to jail. Eventually, he left the Canaries for Madeira (González Lemus 2003, 2012). In Madeira, it is likely that some of the material that Banks and Solander collected came from the gardens and plausibly the herbarium collections of Heberden himself. Interestingly, Heberden wrote a manuscript on the trees growing in Madeira, a copy of which was given to Banks as a gift "together with such specimens as he had in his possession" (entry for September 17 in Banks's journal). It appears that this manuscript by Heberden has not survived as the only publications that he wrote on Madeira concerned the climate and public health of the island as well as astronomical and geological observations and an account on an earthquake that happened in 1761 (Heberden 1990).

Banks and Solander informally named a new genus "Heberdenia" in Heberden's honor. Later, this taxon was effectively published by De Candolle (1841: 79) making reference to Banks's records from Madeira (accepted name *Heberdenia* Banks ex A.DC.). There has been some confusion on the correct species name of this Macaronesian endemic [*Heberdenia excelsa* (Aiton) Banks ex Roem. & Schult. vs. *H. bahamensis* (Gaertn.) Sprague]. Treatments targeting this species indicate *bahamensis* is the correct species epithet for this taxon (De Wit 1957; Ståhl 1996), and this taxonomic arrangement is followed by us.

All of the species in Banks's list were identified with scientific names except four for which specimens without reproductive parts were collected: "Marmulano" (*Sideroxylon mirmulans* R.Br.), "Faya" (*Morella faya* (Aiton) Wilbur), "Pao branco" (*Picconia excelsa* (Aiton) DC.) and "*Salvia major*..." (*Teucrium betonicifolium* Jacq). Banks placed the "Marmulano" in the Linnean class *Hexandria*. Later, Francis Masson (1741-1805), first plant collector of the Royal Botanic Gardens, Kew, who botanized extensively in Madeira, Tenerife, and the Azores (Sao Miguel, Faial, and also possibly São Jorge) between 1776 and 1779 (Francisco-Ortega et al. 2008), found this species again. In a letter he sent to Banks, dated 4th April 1777, Masson indicated that it belonged to the genus *Sideroxylon* L. (Lobin et al. 2005; Santos Guerra et al. in preparation). This interesting tree species was later described by Robert Brown (in Buch, 1825: 193) as *S. mirmulans*.

"Pao branco" the second species that remained unidentified in Banks's list was subsequently described in *Hortus Kewensis* (Aiton 1789a) as *Olea excelsa* Aiton, also based on Masson's collection. Aiton (1789b) used material collected by Masson to describe, the third of these "enigmatic species", the "Faya" that was named *Myrica faya* Aiton. The last of the species that Banks could not place taxonomically, was identified on Banks's list using a *Salvia* polynomial name published by Sloane (1707). Francisco-Ortega et al. (2020) provided a review on the taxonomic history of this taxon indicating that *Teucrium betonicifolium* Jacq. is its correct name.

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 165-220



16. Madera.

DECANDRIA

MONOGYNIA.

bicapsularis. CASSIA. Linn. Sp. pl. 538:6.
Hab.

graveolens. RUTA. Linn. Sp. pl. 548:1.
Arruda. Incolis.
Hab.

arborea. CLETHRA. Mscr. p. 566.
Fig. pict.
Folhada. incolis.
Hab.
Rami glabri teretes, cicatricibus petiolorum tuberculati. Folia petiolata, opposita, dense se invicem approquinquata, ovato-lanceolata, acuta, serrata, utrinque glabra, supra vivide viridia, subtus pallida; plerumque 4½ uncias longa, 1½ lata. Petioli glabri folii quadruplo vel quintuplo breviores. Pedunculi plures ex uno centro, foliis longiores, hirti, interdum ramosi. Flores e rubiginoso-albescentes, svaveolentes in racemos longos simplices dispositi: Pedicellis filiformibus, villosiusculis, æqualibus, trium vel quatuor linearum longitudine.
Perianthium pentaphyllum: foliolis ovatis, obtusis, erectis, concavis, æqualibus, persistentibus, extus pubescentibus.
Petala quinque, patentia, calyce duplo longiora; Unguibus angustatis, brevibus; Laminis obovatis, obtusissimis.
Filamenta decem, capillaria, unguibus corolla paulo longiora, eorumque basi affixa, scilicet duo in singulo petalo. Anthera oblonga, erecta.
Germen inferum, subrotundum, villosum. Stylus filiformis, erectus, persistens, longitudine staminum, (post florescentiam duplo longior.) Stigma trifidum: laciniis filiformibus, simplicibus.
Capsula subrotunda, calyce obvoluta, trivalvis, trilocularis.
Semina plurima.
Nostra differt a Charactere Generico Clethræ in Linn. Gen. plant. p. 221: quod Calyx omnino pentaphyllus, forte ita etjam in Clethra alnifolia Linn. Sp. pl. 566:1. quæ ulterius examinanda, pro differentia specifica meliori.

DIGYNIA.

prolifer. DIANTHUS. Linn. Sp. pl. 587:4.
Gravo brabo. Incolis.
Hab.

Caryophyllus. DIANTHUS. Linn. Sp. pl. 587:6. Hab.

Figure 4. Page 16 of the *Primitiae Florae Maderensis, sive catalogus Plantarum in Insula Madera*, a work that was prepared by Daniel Solander and remained unpublished. From top to bottom: *Senna bicapsularis*, *Ruta graveolens*, *Clethra arborea* (including the full description of this Madeiran endemic), *Petrorhagia prolifera* and *Dianthus caryophyllus*. Image copyright of the Natural History Museum of London.

III. *PRIMITIAE FLORAE MADERENSIS, SIVE CATALOGUS PLANTARUM IN INSULA MADERA* AND EARLY IMPACT OF THE COLLECTIONS

As with other regions visited during the *Endeavour* voyage, a manuscript flora was prepared for Madeira by Solander (*Primitiae Florae Maderensis, sive catalogus Plantarum in Insula Madera*), but it remained unpublished (fig. 4). According to annotations found in this manuscript, this copy was prepared by Sigismund Bacstrom (c.1750-1805) from Germany, who was employed as secretary to Joseph Banks between 1772 and 1775 (Cole 1980). The manuscript comprises the first 41 pages of a manuscript volume entitled "Floras of the Countries visited during Capt. James Cook's first Voyage" (Botany Manuscripts MSS BANKS COLL SOL; barcode 338012). Whilst unpublished, the Madeiran findings of Banks and Solander were relevant for later researchers. For example, in the late 18th century, L'Héritier (1788) studied material collected by Banks and Solander for his description of *Bystropogon punctatus*. Robert Brown (1773-1858), Banks's librarian and later the first keeper of the Banksian (later Botanical) Department of the British Museum, based his first comprehensive list for the Madeiran flora mostly on Masson's collections housed at the BM but the collections made by Banks and Solander were also one of the obvious sources for his study. The actual date when Brown prepared this list is unknown but this floristic account remained unpublished until the works of Buch (1825: 189-199) and Britten (1904). It is noteworthy that Brown himself visited Madeira in 1801 in route to Australia on board HMS *Investigator* (Moore 2001).

Solander's *Primitiae Florae Maderensis, sive catalogus Plantarum in Insula Madera* included 351 entries for 345 taxa. Twenty of these entries refer to polynomial names published by Plukenet and Sloane (revised by Francisco-Ortega et al. 1994 and Menezes de Sequeira et al. 2010). We infer that the remaining entries (331 entries, 325 taxa) are for plants that were recorded or collected in Madeira by Banks and Solander as they match those found in Banks's journal; however, four of these 325 taxa [*Boletus* sp. (Boletaceae), *Bystropogon punctatus* (as *Menthastrum Mentha maderensis* in Solander's list), *Lichen subfuscus* L. (Lecanoraceae), and *Lotus corniculatus* L. (= *L. lancerottensis* Webb & Berthel.) (Fabaceae)] were not listed in Banks's journal. *Lichen subfuscus* [accepted name *Lecanora subfusca* (L.) Ach. (LIAS 1995-2020)] and the fungal genus *Boletus* s.l. both occur in Madeira (Carvalho et al. 2008, Melo and Cardoso 2008) but no herbarium material collected by Banks and Solander was seen during the course of this study. Two of the taxa recorded in Banks's journal (*Campanula erinus* and the garden plant *Gardenia jasminoides*) are not found in *Primitiae Florae Maderensis*.

In this pioneering flora, Solander wrote descriptions for 15 Madeiran/Macaronesian endemics that later were validly published by other taxonomists, namely: "*Alypum longifolium*" (*Globularia salicina*); "*Clethra arborea*" (*C. arborea*, fig. 4), "*Crepis tenuifolia*" (*Tolpis succulenta*, *C. succulenta*); "*Heberdenia excelsa*" (*H. bahamensis*, *Anguillaria bahamensis* Gaertn.), "*Hypericum evectum*" (*H. grandifolium*), "*Hypericum glandulosum*" (*H. glandulosum*), "*Ilex azevinho*" (*I. canariensis*), "*Ilex perado*" (*I. perado* subsp. *perado*), "*Laurus nitida*" (*Apollonias barbujana, L. barbujana* Cav.), "*Lavandula pinnata*" (*L. pinnata*), "*Laurus foetens*" (*Ocotea foetens*, *L. foetens*), "*Lotus glaucus*" (*L. glaucus*), "*Rubus pedatus*" (*R. serrae*), "*Smilax latifolia*" (*S. pendulina*), and "*Vaccinium elevatum*" (*V. padifolium*).

IV. THE HERBARIUM RECORD

Shortly before his death in 1820, Banks bequeathed his herbarium to his librarian Robert Brown on the condition that it would become the property of the British Museum on Brown's death – unless Brown chose to transfer it earlier. Negotiations for its transfer began soon after Banks's death. Favourable terms were agreed and in 1827 the herbarium was transferred with Brown appointed Keeper of the newly formed Banksian Department as part of the agreement. The herbarium was transferred to South Kensington, London in 1881 where it remains today and forms the one of the foundation collections of the Natural History Museum herbarium (BM).

We have found matching herbarium specimens in three different collections of the Natural History Museum herbarium (figs. 5-7), namely (1) the General Herbarium, (2) a bound volume entitled "*Plants of Cook's First Voyage 1768-1771*" held in the Historical Collections Room, and (3) inside a drying book ('Madeira III') made up of loosely bound uncut pages from Adison's *Notes upon the twelve books of Paradise Lost*, published in 1719. This was one of seven bundles of plants resulting from Banks and Solander's collecting activities in Madeira. It is the only one to survive intact and with some specimens still contained within it.

During the course of Cook's voyage specimens were stored inside these drying books [see Groves (1962) for a full account regarding the protocols followed by Banks and Solander in preparing and recording the extensive collections of specimens that were made during this *Endeavour* voyage]. After Banks and Solander's return to Britain this material was removed and subsequently mounted on sheets (material now in the General Herbarium) and/or inside the volumes of "*Plants of Cook's First Voyage 1768-1771*" (Edwards 1978), located in the historical collections room at BM.

In total, there are 210 collections for 206 taxa in the Natural History Museum herbarium. Sixteen of the taxa are Madeiran endemics, 18 are Macaronesian endemics, 100 are non-endemic natives, 60 are introduced, and 12 are cultivated. These specimens represent ten fern and 196 spermatophyte taxa. As the list of material recorded in Banks's journal has 163 introduced taxa, these data show that 44% of the records for introduced taxa lack matching specimens in the herbarium. This suggests that Banks and Solander mostly focused their collecting efforts on plants belonging to the native flora, including the endemics.

One-hundred and ten of these collections (108 taxa) are found only in the General Herbarium, 25 of them (25 taxa) are found only in the bound volume of *Plants of Cook's First Voyage* and 75 (75 taxa) are shared by these two herbarium holdings. Unfortunately it was not possible to fully assess the contents of the drying book (Madeira III) because of its fragility. However, it is clear that the drying book has relatively few specimens and it is unlikely that there are any that are not found in the General Herbarium or the *Plants of Cook First Voyage* bound volume.

Figure 5. Herbarium specimen of *Teucrium betonicifolium* collected by Banks and Solander in Madeira during the *Endeavour* voyage. This is the lectotype of *T. betonicum* L'Hér., as designated by Francisco-Ortega et al. (2020). Image copyright of the Natural History Museum of London.

Figure 6. Sheet with specimens collected by Banks and Solander in Madeira that is part of a bound volume (folio 2) entitled *Plants of Cook's First Voyage 1768-1771* held in the Historical Collections Room of the Natural History Museum of London. Specimens are identified (left to right) as follows: **Top row**: *Globularia salicina*, *Galium productum*, *Ilex perado perado* subsp. **Second row from top**: *Ilex canariensis*, *Heberdenia bahamensis*, *Achyranthes sicula*. **Third row from top**: *Chenopodium album*, *Ammi visnaga*, *Juncus effusus*, *Linum bienne*. **Bottom row**: *Rumex maderensis*, *Vaccinium padifolium*, *Sibthorpia peregrina*, *Polygonum aviculare*. Image copyright of the Natural History Museum of London.

The Drying Book Inventory

The Natural History Museum library houses a further list of Madeiran plants that forms part of a manuscript entitled 'Catalogue of the plants collected at Madeira, Brazil, Tierra del Fuego and the Society Islands' (31pp, Botany Manus-

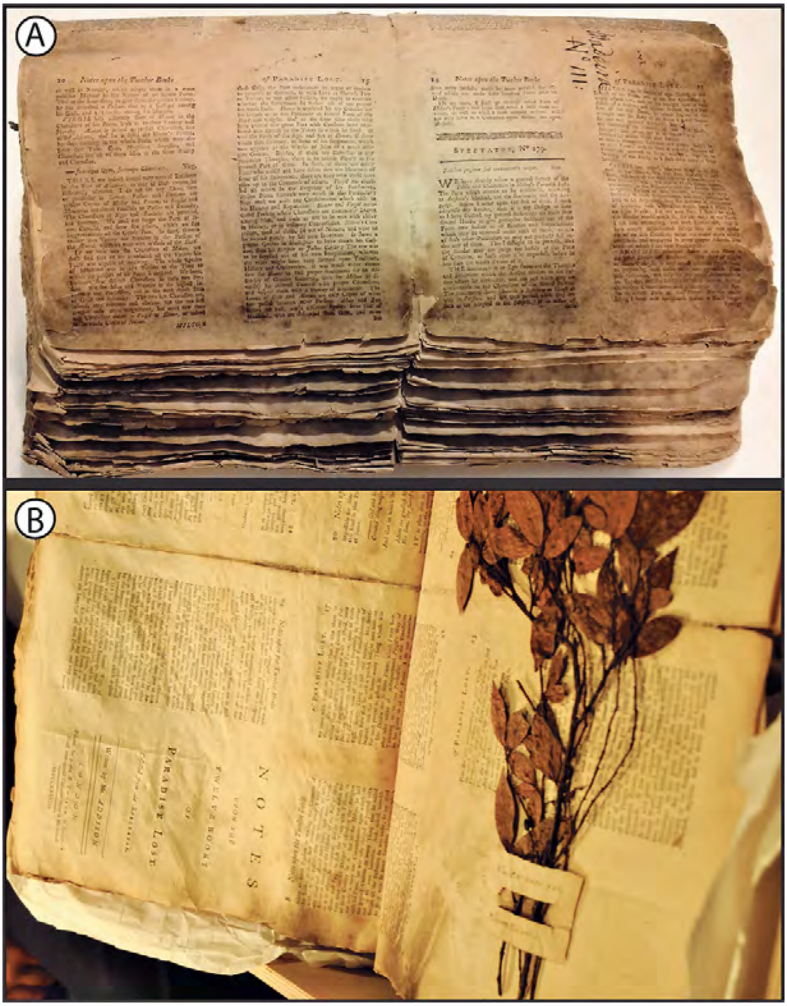
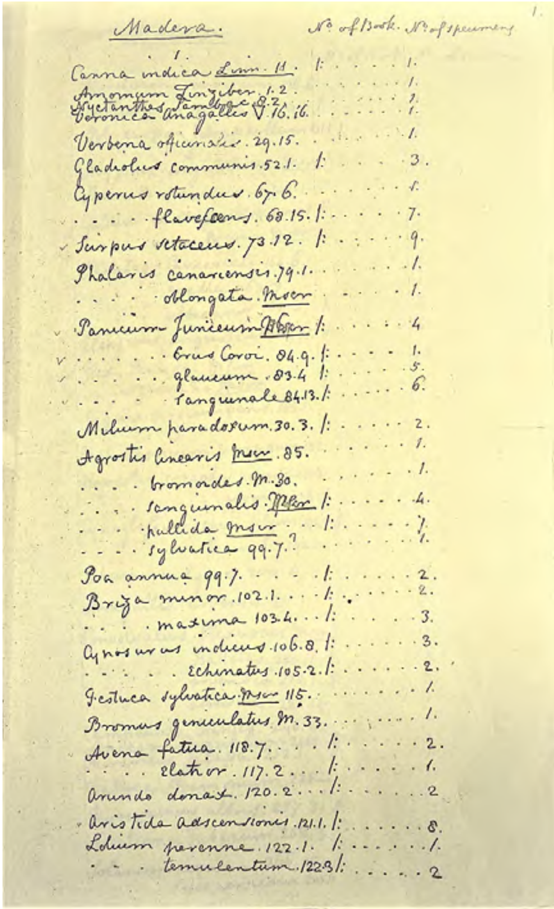


Figure 7. Drying book (Madeira III) that contains plant specimens collected in Madeira during the visit of *Endeavour* from 12-18 September, 1768. **A**: General view of the bundle that makes this particular drying book. **B**: Specimen of *Vaccinium padifolium*, notice that the bottom of folio that faces the specimen has the full title of one of the uncut pages of the book that was used to dry plants during the expedition. Image copyright of the Natural History Museum of London.

cripts MSS BANKS COLL; barcode 138798). It documents 256 entries (252 taxa) for spermatophytes (231 taxa), ferns (11 taxa), algae (one taxon), mosses (two taxa), liverworts (two taxa), and lichens (5 taxa) for which herbarium material was collected in Madeira (fig. 8). The last page of this manuscript erroneously indicates that it



Madera. — Nº of Book. — Nº of specimens — 1.

Canna indica Linn. 11. 1: . . . 1.
Amomum Zingiber. 1.2. . . . 1.
Nyctanthes Sambac 6.2 . . . 1.
Veronica Anagallis 16.16. . . . 1.
Verbena officinalis. 29.15. . . . 1.
Gladiolus communis. 52.1. 1: . . . 3.
Cyperus rotundus. 67.6. . . . 1.
. . . flavescens. 68.15. 1: . . . 7.
Scirpus setaceus. 73.12. 1: . . . 9.
Phalaris canariensis. 79.1. . . . 1.
. . . oblongata. Mscr . . . 1.
Panicum Junceum Mscr 1: . . . 4
. . . Crus Corvi. 84.9. 1: . . . 1.
. . . glaucum. 83.4 1: . . . 5.
. . . sanguinale 84.13. 1: . . . 6.
Milium paradoxum. 30.3. 1: . . . 2.
Agrostis linearis Mscr. 85. . . . 1.
. . . bromoides. M. 30. . . . 1.
. . . sanguinalis Mscr 1: . . . 4.
. . . pallida Mscr 1: . . . 7.
. . . sylvatica 99.7. ? . . . 1.
Poa annua 99.7. 1: . . . 2.
Briza minor. 102.1. 1: . . . 2.
. . . maxima 103.4. 1: . . . 3.
Cynosurus indicus. 106.8. 1: . . . 3.
. . . echinatus. 105.2. 1: . . . 2.
Festuca sylvatica Mscr 115. . . . 1.
Bromus geniculatus M. 33. . . . 1.
Avena fatua. 118.7. 1: . . . 2.
. . . elatior. 117.2. 1: . . . 1.
Arundo donax. 120.2. 1: . . . 2
Aristida adscensionis. 121.1. 1: . . . 8.
Lolium perenne. 122.1. 1: . . . 1.
. . . temulentum. 122.3 1: . . . 2

Figure 8. First folio of the eight folio list (256 entries) that has an inventory of the Madeiran collections made by Banks and Solander. This is part of the index to specimens that were stored inside drying books during Cook's voyage. Numbers after each name refer to the page and plant numbers in the second edition of Linnaeus' (1762, 1763) *Species plantarum*. "Nº of Book" refers to the drying book number where the specimen was stored. The number of specimens made per collection is also indicated. The 34 plant entries listed in this page match entries found in the first two pages of the list of material included in Banks's journal. Image copyright of the Natural History Museum of London.

comprises 253 entries instead of 256. Based on notes written on this manuscript by Eric W. Groves (1923-2012) in 1982, it appears that this list was written by Banks.

All of the entries with the exception of *Lotus corniculatus* (= *L. lancerottensis*), *Lichen subfuscus* (see above discussion regarding the status of these two species in Banks's collections), and *Bystropogon punctatus* are also recorded in the list of plants

REVISTA SCIENTIA INSULARUM, 3; 2020, PP. 165-220

in Banks's journal. The manuscript is an inventory of the material that was placed inside the drying books during the first part of the *Endeavour* voyage. It provides details of the number of duplicates made for each collection and the drying book in which each collection was stored (numbered I through VII for Madeira). The five species with the highest number of duplicates were *Apollonias barbujana* (14 duplicates), *Heberdenia bahamensis* (20 duplicates), *Ilex perado* (13 duplicates), *Lythrum hyssopifolia* (14 duplicates), and *Ocotea foetens* (14 duplicates). Four species (*Acanthus mollis*, *Chelidonium majus*, *Equisetum arvense*, and *Tropaeolum majus*) with matching specimens in BM were not found in this manuscript but were included both in Solanders' *Primitiae Florae Maderiensis* and in Bank's journal list.

For 59 (23%) of the 252 taxa listed in this inventory, there are no matching specimens in BM. Twenty-five of these taxa are introduced, three have been identified as Madeiran endemics (*Aichryson divaricatum*, *Hedera maderensis*, and *Sideritis candicans*). Among the 25 non-endemic natives that lack specimens, one is an alga, five are lichens, four are bryophytes, two are ferns, and the remaining 13 are spermatophytes. The fate of these specimens is not clear. However, we do know that when the Banksian herbarium was transferred from his house in Soho Square to the British Museum in 1827, a substantial proportion was unmounted [estimated by Brown in 1834 to comprise 1700 bundles (Murray 1904: 80)]. The missing specimens may have been lost between the point of collection and their eventual processing for the herbarium. Furthermore, bomb damage to the BM herbarium during the Second World War affected Banks's collections (Groves 1962) and could also account for the absence of some specimens.

V. TAXONOMIC UPDATE OF THE LIST OF MADEIRAN VASCULAR PLANTS, BRYOPHYTES, LICHENS, AND ALGAE REPORTED IN BANKS'S JOURNAL

Below we provide a transcription of the list of vascular plants, bryophytes lichens, and algae recorded in Madeira as found in Banks's journal housed in the State Library of New South Wales, Australia. Entries are presented in the same order as they were listed by Banks which followed Linnean orders. For each entry we assign sequential entry numbers to help the reader to locate each of these records. These were not in the original list. Appendix 1 provides a taxonomic index that ties the identified species with the particular entries found in Banks's list. For each entry we transcribed the name as written in Banks lists, this is followed by text inside brackets that provides the accepted scientific name. We also provide information on status using the following abbreviations: **Cult.** = Cultivated, **Intr.** = Naturalized non-natives, **Nat.** = Non-endemic natives, **Mad.** = Madeira endemics, **Mac.** = Macaronesian endemics, **Notes** = Additional comments. For the most part, notes concern determinations provided by taxonomic experts. Where there is no indication that the specimen was revised for the Flora of Madeira project (Press and Short 1994), that was based at BM, this is indicated. We list specimens for each entry herbarium collections at the BM (**Herb.**) following this code: GH = General herbarium of the

Natural History Museum of London, SCV = Volume with specimens from Cook's first voyage. Concerning entries recorded in the two other documents (**Other lists**), the following code is followed: NPL = Banks's index for specimens that were stored inside the drying books; SOL = Solander's *Primitiae Florae Maderensis*.

Sources to check the current presence of these taxa in Madeira were Press and Short (1994; hereafter Flora of Madeira in "Notes"), Carvalho et al. (2008), Jardim and Menezes de Sequeira (2008), Melo and Cardoso (2008), Sérgio et al. (2008), and Menezes de Sequeira et al. (2012).

Our taxonomic identifications are based on the study of the available herbarium material collected by Banks and Solander. For those entries for which no specimens were located, taxonomic inferences were based on: (1) the scientific and common names reported in Banks and Solander's lists; (2) references to names reported in the second edition of Linnaeus's (1762, 1763) *Species plantarum;* and (3) other sources. References to Linnaeus (1762, 1763) are found in Solander's *Primitiae Florae Maderensis, sive catalogus Plantarum in Insula Madera* and in the inventory of specimens that is part of the *Catalogue of the plants collected at Madeira, Brazil, Tierra del Fuego and the Society Islands*. References to Linnean names and works (mostly to *Species Plantarum* or *Mantissa*) were also found on the original labels of several of the studied specimens. When our contribution was submitted, BM was shut because of the coronavirus pandemic. Therefore we could not double check herbarium specimens for entries 52 and 202; we have tentatively assigned them to *Plantago major* and *Sida spinosa*, respectively.

[Page 1] Plants of Madeira

N.B. the mark of a start * in the margin signifies that the plant so marked is not wild but cultivated a cross + that for want of firmely =ication [identification] the plant could not certainly be determind [determinated]

Monandria

=1.- Canna indica Linn. Bananeira brava. Conteira preta. [*Canna indica* L. (Cannaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=2.- *Amomun Zingiber Linn. [*Zingiber officinale* Roscoe (Zingiberaeae);]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: "ex Hort" on sheet back.

=3.- Callitriche verna Linn. [*Callitriche stagnalis* Scop. (Plantaginaceae)]; **Nat.**; **Other lists**: SOL.

Diandria

=4.- *Nyctanthes sambac Linn. Flore pleno. [*Jasminum sambac* (L.) Aiton (Oleaceae)]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=5.- *Jasminum officinale Linn. [*Jasminum officinale* L. (Oleaceae)]; **Cult.**; **Other lists**: SOL.

=6.- Jasminum grandiflorum Linn. [*Jasminum grandiflorum* L. (Oleaceae)]; **Cult.**; **Other lists**: SOL.

=7.- +Olea europea Linn. [*Olea maderensis* (Lowe) Rivas Mart. & del Arco (Oleaceae)]; **Mad.**; **Herb.**: GH; **Other lists**: SOL; **Notes**: Revised by Lowe.

=8.- Veronica anagallis ∇ Linn. [*Veronica anagallis-aquatica* L. (Scrophulariaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL.

=9.- Verbena officinalis Linn. [*Verbena officinalis* L. (Verbenaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=10.- *Rosmarinus officinalis Linn. [*Rosmarinus officinalis* L. (Lamiaceae)]; **Cult.**; **Other lists**: SOL.

=11.- *Salvia officinalis Linn. [*Salvia officinalis* L. (Lamiaceae)]; **Cult.**; **Other lists**: SOL.

Triandria

=12.- Gladiolus communis Linn. Alho brabo. [*Gladiolus* cf. *italicus* Mill. (Iridaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL.

=13.- Iris [*Iris* sp. (Iridaceae)]; **Intr.** and **Cult.**; **Other lists**: SOL.

=14.- Cyperus rotundus Linn. [*Cyperus rotundus* L. (Cyperaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=15.- Cyperus flavescens Linn. [*Pycreus flavescens* (L.) Rchb. (Cyperaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=16.- Scirpus setaceus Linn. [*Isolepis setacea* (L.) R.Br. (Cyperaceae)]; **Nat.**; **Herb.**: GH (BM000829271), SCV; **Other lists**: NPL, SOL.

=17.- *Saccharum officinarum Linn. [*Saccharum officinarum* L. (Poaceae)]; **Cult.**; **Other lists**: SOL.

=18.- Phalaris canariensis Linn. [*Phalaris canariensis* L. (Poaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=19.- Phalaris oblongata Mss. [*Phalaris coerulescens* Desf. (Poaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by T.A. Cope, 18.V.1989.

=20.- Panicum Junceum Mscr. [crossed] Grama [*Panicum repens* L. (Poaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

[Page] 2 Plants of Madeira

=21.- Panicum glaucum Linn. [*Pennisetum glaucum* (L.) R.Br. (Poaceae)]; **Intr.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=22.- Panicum sanguinale Linn. [*Digitaria sanguinalis* (L.) Scop. (Poaceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Confirmed by T.A. Cope 18.V.1989, for Flora of Madeira.

Panicum glaucum Linn.[crossed]

=23-. --------- Cruz Corvi Linn. Milhoa Lus. [*Echinochloa colona* (L.) Link (Poaceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Confirmed by T.A. Cope, 18.V.1982 included in the sheet there is another specimen determinated as *Echinochloa crus-galli* (L). P. Beauv.

=24.- Milium paradoxum Linn. [*Oryzopsis miliacea* (L.) Asch. & Scheweinf. (Poaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL; **Notes**: This species is listed as *Piptatherum miliaceum* (L.) Coss. subsp. *miliaceum* by Menezes de Sequeira et al. (2012).

=25.- Agrostis linearis Mscr. [*Agrostis* sp. (Poaceae)]; **Other lists**: NPL, SOL.

=26.- --------- bromoides Linn. [*Vulpia bromoides* (L.) Gray (Poaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: "In apricis Mantissa 30" in the original label. Confirmed by T.A. Cope, 21.VII.1989.

=27.- ---------- sanguinalis Mscr. [*Digitaria ciliaris* (Retz.) Koeler. (Poaceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL.

=28.- --------- pallida Mscr. [*Gastridium ventricosum* (Gouan) Schinz & Thell. (Poaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=29.- --------- sylvatica Linn. [*Polypogon viridis* (Gouan) Breist. (Poaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=30.- Poa annua Linn. [*Poa annua* L. (Poaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Confirmed by T.A. Cope, 21.VII.1989.

=31.- Briza minor Linn. [*Briza minor* L. (Poaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised by T.A. Cope, 21.VII.1989, for Flora of Madeira.

=32.- --------- maxima Linn. Xucalheira Lus. [*Briza maxima* L. (Poaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised by T.A. Cope, 21.VII.1989, for Flora of Madeira.

=33.- Cynosurus indicus Linn. [*Eleusine indica* (L.) Gaertn. (Poaceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Confirmed by T.A. Cope, 7.XII.1988.

=34.- --------- echinatus Linn. [*Cynosurus echinatus* L. (Poaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=35.- Festuca sylvatica Mscr. Bromus pinnatus Linn. [*Brachypodium sylvaticum* (Huds.) P.Beauv. (Poaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Confirmed by T. A. Cope, 8.X.1988, for Flora of Madeira.

=36.- Bromus geniculatus Linn. [*Bromus madritensis* L. (Poaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Revised by T.A. Cope, 8.X.1988, for Flora of Madeira.

=37.- Avena fatua Linn. Balanco Lus. [*Avena barbata* Pott ex Link (Poaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Confirmed by T.A. Cope, 13.IV.1989, for Flora of Madeira.

=38.- --------- elatior Linn. [*Arrhenatherum elatius* (L.) J.Presl & C. Presl subsp. *bulbosum* (Willd.) Schübl. & G. Martens (Poaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=39.- --------- nodosa Linn. [*Arrhenatherum elatius* (L.) J.Presl & C.Presl subsp. *bulbosum* (Willd.) Schübl. & G. Martens (Poaceae)]; **Nat.**; **Other lists**: SOL.

=40.- Arundo donax Linn. Canavieira Lus. [*Arundo donax* L. (Poaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=41.- Aristida Adscentionis Linn. [*Aristida adscensionis* L. (Poaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=42.- Lolium perenne Linn. [*Lolium perenne* L. (Poaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=43.- --------- temulentum Linn. [*Lolium temulentum* L. (Poaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=44.- Hordeum murinum Linn. [*Hordeum murinum* L. subsp. *glaucum* (Steudel) Tzvelev (Poaceae)]; **Nat.**; **Herb.**: GH (BM000060788); **Other lists**: NPL, SOL; **Notes**: Determined by T.A. Cope, 8.X.1988.

=45.- Triticum repens Linn. Forocapa Lus. [*Elymus repens* (L.) Gould (Poaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=46.- Polycarpon tetraphyllum Linn. Saboira Lus. [*Polycarpon tetraphyllum* (L.) L. (Caryophyllaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

[Page] 3 Plants of Madeira

TETRANDRIA

=47.- Alypum angustifolium Fig. pict. Mscr. Malforada Lus. [*Globularia salicina* Lam. (Globulariaceae)]; **Mac.**; **Herb.**: GH (BM000999098, BM000999099), SCV; **Other lists**: NPL, SOL; **Notes**: Listed as "Alypum longifolium Mscr." in NPL and SOL. Not revised for Flora of Madeira.

=48.- Sherardia arvensis Linn. [*Sherardia arvensis* L. (Rubiaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=49.- Galium mollugo Linn. var. angustifolia [*Galium productum* Lowe (Rubiaceae)]; **Mad.**; **Herb.**: GH (BM000829004, BM000829002), SCV; **Other lists**: NPL, SOL; **Notes**: The original label states: " in Madera locus saxocis prope rivulos". The General Herbarium sheet also includes two fragments of *G. parisiense* L. (BM000829003). Determined by N.J. Turland, VI.1993.

=50.- --------- vesiculosum Mscr. [*Galium verrucosum* Huds. (Rubiaceae)]; **Nat.**; **Herb.**: GH (BM000829036); **Other lists**: NPL, SOL; **Notes**: Determined by N.J. Turland, VI.1993.

=51.- Plantago lanceolata Linn. [*Plantago lagopus* L. (Plantaginaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, VIII.1997, for Flora of Madeira.

=52.- --------- media Linn. Tanxage Lus. [*Plantago major* L. (Plantaginaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL.

=53.- --------- albicans Linn. [*Plantago lagopus* L. and *P. lanceolata* L. (Plantaginaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: According to J.R. Press the sheet includes one specimen of *Plantago lanceolata* L. and another one of *P. lagopus* L, determinated on VIII.1991.

=54.- Eleagnus angustifolia Linn. Oleveira Lus. [*Olea maderensis* (Lowe) Rivas Mart. & del Arco (Oleaceae)]; **Mad.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=55.- Ilex Perado Mss. Perado Lus. fig. pict. [*Ilex perado* Aiton subsp. *perado* (Aquifoliaceae)]; **Mad.**; **Herb.**: GH (BM000536466), SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=56.- + --------- Azevinho Mss. Azevinho Lus. fig. pict. [*Ilex canariensis* Poir. (Aquifoliaceae)]; **Mac.**; **Herb.**: SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=57.- Sagina procumbens Linn. [*Sagina procumbens* L. (Caryophyllaceae)]; **Nat.**; **Herb.**: GH (BM000072032); **Other lists**: NPL, SOL; **Notes**: Determined by M.J. West, I.1992.

PENTANDRIA

=58.- Heliotropium europaeum Linn. [*Heliotropium europaeum* L. (Boraginaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=59.- Myosotis scorpioides palustris Linn. [*Myosotis secunda* Al. Murray (Boraginaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by M.J. West, II.1991.

=60.- --------- ---------- arvensis Linn. [*Myosotis arvensis* (L.) Hill (Boraginaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=61.- Cynoglossum cheirifolium Linn. Masarogueira Lus. [*Cynoglossum creticum* Mill. (Boraginaceae)]; **Nat.**; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=62.- --------- officinale Linn. [*Cynoglossum creticum* Mill. (Boraginaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=63.- Echium vulgare Linn. [*Echium plantagineum* L. (Boraginaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL.

=64.- Anagallis arvensis Linn. [*Anagallis arvensis* L. (Primulaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=65.- Convolvulus flexuosus Mss. [*Convolvulus althaeoides* L. (Convolvulaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Examined by Lowe. Not revised for Flora of Madeira.

=66.- *--------- Batatas Linn. Batata Lus. [*Ipomoea batatas* (L.) Lam. (Convolvulaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=67.- --------- arvensis Linn. corriola Lus. [*Convolvulus arvensis* L. (Convolvulaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=68.- --------- altheoides Linn. [*Convolvulus althaeoides* L. (Convolvulaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=69.- Campanula erinus Linn. [*Campanula erinus* L. (Campanulaceae)]; **Nat.**; **Other lists**: SOL; **Notes**: Not revised for Flora of Madeira.

=70.- Lonicera caprifolium Linn. [*Lonicera caprifolium* L. (Caprifoliaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=71.- Mirabilis Jalapa Linn. Boninas Lus. [*Mirabilis jalapa* L. (Nyctaginaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, VII.1987, for Flora of Madeira.

=72.- Datura Stramonium Linn. Bufareira Lus. [*Datura stramonium* L. (Solanaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=73.- Hyosciamus albus Linn. Maimiendro Lus. [*Hyoscyamus albus* L. (Solanaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=74.- Nicotiana Tabacum Linn. Erva santa Lus. [*Nicotiana tabacum* L. (Solanaceae)]; **Intr.**; **Herb.**: GH (BM000940645); **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=75.- *Solanum tuberosum Linn. [*Solanum tuberosum* L. (Solanaceae)]; **Cult.**; **Other lists**: SOL.

=76.- --------- nigrum Linn. [*Solanum americanum* Mill. (Solanaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determinated by Sandra Knapp, 2008.

=77.- --------- pseudocapsicum Linn. Pimenteira Lus. [*Solanum pseudocapsicum* L. (Solanaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=78.- --------- Lycopersicum Linn. Tomatos Lus. [*Lycopersicon esculentum* Mill. (Solanaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL.

=79.- Capsicum frutescens α Linn. [*Capsicum annuum* L. (Solanaceae)]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by J.M. Eylmons, 16.II.2005.

=80.- Heberdenia excelsa Mscr. Aderno Lus. fig. pict. [*Heberdenia bahamensis* (Gaertn.) Sprague (Primulaceae)]; **Mac.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=81.- Lycium barbarum Linn. Espinheiro Lus. [*Lycium europaeum* L. (Solanaceae)]; **Nat.**; **Herb.**: GH (BM001019044); **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=82.- *Mangifera indica Linn. Mangoira Lus. [*Mangifera indica* L. (Anacardiaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=83.- *Ribes rubrum Linn. [*Ribes rubrum* L. (Grossulariaceae)]; **Cult.**; **Other lists**: SOL.

=84.- *--------- grossularia Linn. [*Ribes grossularia* L. (Grossulariaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=85.- Hedera helix Linn. [*Hedera maderensis* K. Koch ex A.Rutherf. (Araliaceae)]; **Mad.**; **Other lists**: NPL, SOL.

=86.- *Vitis vinifera Linn. [*Vitis vinifera* L. (Vitaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=87.- Achyranthes aspera Sicula Linn. [*Achyranthes sicula* (L.) All. (Amaranthaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=88.- *Celosia cristata Linn. [*Celosia argentea* L. (Amaranthaceae)]; **Cult.**; **Other lists**: SOL.

=89.- *Gardenia florida Linn. [*Gardenia jasminoides* J. Ellis (Rubiaceae)]; **Cult.**

=90.- Chenopodium murale Linn. [*Chenopodium murale* L. (Chenopodiaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, 3.VIII.1987, for Flora of Madeira.

=91.- --------- album Linn. [*Chenopodium album* L. (Chenopodiaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=92.- --------- ambrosioides Linn. [*Chenopodium ambrosioides* L. (Chenopodiaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Confirmed by J.R. Press, 4.VIII.1987, for Flora of Madeira.

=93.- Caucalis arvensis Mss. [*Torilis arvensis* (Huds.) Link subsp. *neglecta* (Spreng.) Thell. (Apiaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determinated by M. J. Cannon, 1989.

=94.- Daucus visnaga Linn. Bisnaga Lus. [*Ammi visnaga* (L.) Lam. (Apiaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determinated by M.J. Cannon, 1989.

=95.- Ammi majus Linn. Margaca Lus. [*Ammi majus* L. (Apiaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=96.- Sium nodiflorum? Linn. Rabassa Lus. [*Apium nodiflorum* (L.) Lag. (Apiaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=97.- Anethum Foeniculum Linn. Funcho Lus. [*Foeniculum vulgare* Mill. (Apiaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=98.- Apium petroselinum Linn. [*Petroselinum crispum* (Mill.) Fuss (Apiaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=99.- Rhus coriaria Linn. Sumagre Lus. [*Rhus coriaria* L. (Anacardiaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=100.- Sambucus ebulus Linn. [*Sambucus ebulus* L. (Caprifoliaceae)]; **Intr.**; **Other lists**: SOL.

=101.- Alsine media Linn. [*Stellaria media* (L.) Vill. (Caryophyllaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL.

=102.- Linum perenne Linn. [*Linum bienne* Mill. (Linaceae)]; **Nat.**; **Herb.**: GH (BM000056186), SCV; **Other lists**: NPL, SOL; **Notes**: Determinated by M.J. Short, I.1988, for Flora of Madeira.

[Page] 5 Plants of Madeira

Hexandria

=103.- *Bromelia Ananas Linn. [*Ananas comosus* (L.) Merr. (Bromeliaceae)]; **Cult.**; **Other lists**: SOL.

=104.- Amaryllis belladonna Linn. [*Amaryllis belladonna* L. (Amaryllidaceae)]; **Intr.**; **Com.**; **Other lists**: SOL.

=105.- Allium oleraceum Linn. Sabolinho bracco Lus. [*Allium dentiferum* Webb &Berthel. (Alliaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by A. Seregrin, 4.VIII.2003. According to Brullo et al. (2009) the species is present at Madeira.

=106.- *--------- cepa Linn. [*Allium cepa* L. (Alliaceae)]; **Cult.**; **Other lists**: SOL.

=107.- Lilium candidum Linn. [*Lilium candidum* L. (Liliaceae)]; **Cult.**; **Other lists**: SOL.

=108.- Dracaena Draco Linn. [*Dracaena draco* (L.) L. (Asparagaceae)]; **Mac.**; **Other lists**: SOL.

=109.- Aloe perfoliata Linn. [*Aloe vera* (L.) Burm.f. (Aloaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=110.- *Agave Americana Linn. [*Agave americana* L. (Agavaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=111.- Juncus Effusus Linn. [*Juncus effusus* L. (Juncaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=112.- --------- tenax Mscr. [*Juncus inflexus* L. (Juncaceae)]; **Nat.**; **Herb.**: GH (BM001042040); **Other lists**: NPL, SOL; **Notes**: Determined by Sven Snogerup, 1973.

=113.- Meadia repens Mscr. Erva branca. Erva terra. Lus. fig. pict. [*Sibthorpia peregrina* L. (Scrophulariaceae)]; **Mad.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=114.- Rumex aquaticus Linn. azeda Lus. [*Rumex conglomeratus* Murray (Polygonaceae)]; **Intr.**; **Herb.**: GH (BM00056218); **Other lists**: NPL, SOL; **Notes**: Determined without indication of author.

=115.- --------- scutatus Linn. Labassa Lus. [*Rumex maderensis* Lowe (Polygonaceae)]; **Mac.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=116.- Mermulano Heb. Mss. [*Sideroxylon mirmulans* R.Br. (Sapotaceae)]; **Mad.**; **Herb.**: GH (BM0004398, BM000030980, BM000030981), SCV; **Other lists**: NPL, SOL; **Notes**: One of the sheets have the original label: "Mirmulano, Conf.: Heberden". Revised by T. Leyens & W. Lobin, VI.1994.

Octandria

=117.- Tropaeolum minus Linn. [*Tropaeolum majus* L. (Tropaeolaceae)]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=118.- Vaccinium elevatum Mss. Uveira Lus. [*Vaccinium padifolium* Sm. (Ericaceae)]; **Mad.**; **Herb.**: GH (BM000829320); SCV; **Other lists**: NPL; **Notes**: Listed as "Vaccinium exaltatum Mscr." in NPL and SOL. A specimen of this species was located inside the Driying Book (Madeira III bundle), see Fig. 7.

=119.- Erica cinerea? Linn. [*Erica maderensis* (Benth.) Bornm. (Ericaceae)]; **Mad.**; **Other lists**: NPL, SOL.

=120.- Polygonum aviculare Linn. Sempre noiva Lus. [*Polygonum aviculare* L. (Polygonaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=121.- --------- Hydropiper Linn. Polgueira Lus. [*Persicaria hydropiper* (L.) Spach (Polygonaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL.

=122.- --------- Barbatum Linn. [*Persicaria hydropiper* (L.) Spach (Polygonaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determinated by J.R. Press as *Polygonum hydropiper*, 1.I.1990.

Enneandria

=123.- Laurus nobilis Linn. [*Laurus novocanariensis* Rivas Mart. et al. (Lauraceae)]; **Mac.**; **Herb.**: GH (BM000829064), SCV; **Other lists**: NPL, SOL.

=124.- --------- indica Linn. [*Persea indica* (L.) Spreng. (Lauraceae)]; **Mac.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=125.- --------- nitida Mscr. fig. pict. [*Apollonias barbujana* (Cav.) Bornm. subsp. *barbujana* (Lauraceae)]; **Mac.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by M.J. Short, II.94.

=126.- --------- foetens Mscr. fig. pict. Til Lus. [*Ocotea foetens* (Aiton) Baill. (Lauraceae)]; **Mac.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=127.- *--------- cinamomum Linn. [*Cinnamomum verum* J.Presl (Lauraceae)]; **Cult.**; **Other lists**: SOL.

[Page] 6 Plants of Madeira

Decandria

=128.- Cassia bicapsularis Linn. [*Senna bicapsularis* (L.) Roxb. (Fabaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=129.- Ruta graveolens Linn. Arruda Lus. [*Ruta chalepensis* L. (Rutaceae)]; **Intr.**; **Herb.**: GH (BM000083037); **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=130.- Clethra arborea Mscr. Folhada Lus. fig. pict. [*Clethra arborea* Aiton (Clethraceae)]; **Mad.**; **Herb.**: GH (BM000829091, BM000829092, BM000829093), SCV; **Other lists**: NPL, SOL; **Notes**: Aprovavit J.R. Press, 1991.

=131.- Dianthus prolifer Linn. [*Petrorhagia nanteuilli* (Burnat) P.W. Ball & Heywood (Caryophyllaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL.

=132.- *--------- cariophyllus Linn. [*Dianthus caryophyllus* L. (Caryophyllaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=133.- Cucubalus Behen Linn. Estralho Lus. [*Silene vulgaris* (Moench) Garcke subsp. *vulgaris* (Caryophyllaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=134.- Silene gallica Linn. [*Silene gallica* L. (Caryophyllaceae)]; **Nat.**; **Herb.**: GH (BM000072059), SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=135.- --------- inaperta Linn. [*Silene inaperta* L. (Caryophyllaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=136.- Stellaria graminea Linn. [*Stellaria alsine* Grimm (Caryophyllaceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=137.- Cotyledon umbilicus ♀ Linn. [*Umbilicus rupestris* (Salisb.) Dandy (Crassulaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=138.- Oxalis corniculata Linn. Pedepassaro, Bolsa de pastor Lus. [*Oxalis corniculata* L. (Oxalidaceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by A. Lousteig, 1974, as var. *villosa* (M. Bieb.) Hohen.

=139.- Cerastium viscosum Linn. [*Cerastium glomeratum* Thuill. (Caryophyllaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=140.- *Phytolacca decandra Linn. [*Phytolacca americana* L. (Phytolaccaceae)]; **Intr.**; **Other lists**: SOL.

Dodecandria

=141.- Portulaca oleracea Linn. Baldruegas Lus. [*Portulaca oleracea* L. subsp. *oleracea* (Portulacaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Revised by M.J. Short, VI.1990, for Flora of Madeira.

=142.- Lythrum Hyssopifolia Linn. [*Lythrum hyssopifolia* L. (Lythraceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL.

=143.- Agrimonia eupatoria Linn. [*Agrimonia eupatoria* L. (Rosaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=144.- Reseda luteola Linn. [*Reseda luteola* L. (Resedaceae);]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: species historically cultivated for dyeing. Not revised for Flora of Madeira.

=145.- Euphorbia peplus Linn. [*Euphorbia peplus* L. (Euphorbiaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=146.- ---------- verrucosa Linn. Truivisco Lus. [*Euphorbia platyphyllos* L. (Euphorbiaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised by J.M. Short, 9.VII.1987, for Flora of Madeira.

=147.- Sempervivum arboreum Linn. [*Aichryson divaricatum* (Aiton) Praeger (Crassulaceae)]; **Mad.**; **Other lists**: NPL, SOL; **Notes**: Revised by Lowe.

Icosandria

=148.- Cactus Ficus indica Linn. [*Opuntia ficus-barbarica* A. Berger (Cactaceae)]; **Intr.**; **Other lists**: SOL.

=149.- *Psidium pyriferum Linn. [*Psidium guajava* L. (Myrtaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=150.- *Eugenia Jambos Linn. [*Syzygium jambos* (L.) Alston (Myrtaceae)]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by N.J. Turland, IV.1994.

=151.- Myrtus communis Lusitanica Linn. Myrto Lus. [*Myrtus communis* L. subsp. *communis* (Myrtaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=152.- *--------- tarentina Linn. [*Myrtus communis* L. subsp. *tarentina* (L.) Nyman (Myrtaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=153.- *--------- pulposa Mss. [*Eugenia uniflora* L. (Myrtaceae)]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Listed as "Eugenia pulposa Mscr." in NPL and SOL. Not revised for Flora of Madeira.

[Page] 7 Plants of Madeira

=154.- Punica granatum Linn. [*Punica granatum* L. (Punicaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=155.- *Amygdalus persica Linn. [*Prunus persica* (L.) Batsch (Rosaceae)]; **Cult.**; **Other lists**: SOL.

=156.- *Prunus armenaica Linn. [*Prunus armeniaca* L. (Rosaceae)]; **Cult.**; **Other lists**: SOL.

=157.- *--------- cerasus Linn. [*Prunus cerasus* L. (Rosaceae)]; **Intr.**; **Other lists**: SOL.

=158.- *--------- domestica Linn. [*Prunus domestica* L. (Rosaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=159.- *Mespilus germanica Linn. [*Mespilus germanica* L. (Rosaceae)]; **Cult.**; **Other lists**: SOL.

=160.- *Pyrus communis Linn. [*Pyrus communis* L. (Rosaceae)]; **Cult.**; **Other lists**: SOL.

=161.- *--------- Malus Linn. [*Malus pumila* Mill. (Rosaceae)]; **Cult.**; **Other lists**: SOL.

=162.- *--------- Cydonia Linn. [*Cydonia oblonga* Mill. (Rosaceae)]; **Cult.**; **Other lists**: SOL.

=163.- *Rosa gallica Linn. flore albo. [*Rosa gallica* L. (Rosaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=164.- Rubus pedatus Mss. Silva Lus. [*Rubus serrae* Solano (Rosaceae)]; **Mad.**; **Herb.**: GH (BM00099774); **Other lists**: NPL, SOL; **Notes**: Taxonomy follows Matzke Hajek et al. (2016). Determined by N.J. Turland, III.1993 as *R. grandifolius* Lowe.

=165.- --------- fruticosus Linn. [*Rubus ulmifolius* Schott (Rosaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=166.- *Fragaria vesca Linn. [*Fragaria vesca* L. subsp. *vesca* (Rosaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=167.- Potentilla reptans Linn. [*Potentilla reptans* L. (Rosaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

Polyandria

=168.- Chelidonium majus Linn. Seredonia/Celedonia Lus. [*Chelidonium majus* L. (Papaveraceae)]; **Nat.**; **Herb.**: GH; **Other lists**: SOL; **Notes**: Not revised for Flora of Madeira.

=169.- Delphinium consolida Linn. [*Consolida ajacis* (L.) Schur (Ranunculaceae)]; **Intr.**; **Other lists**: SOL.

=170.- Nigella damascena Linn. [*Nigella damascena* L. (Ranunculaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=171.- *Liriodendrum tulipifera Linn. [*Liriodendron tulipifera* L. (Magnoliaceae)]; **Cult.**; **Other lists**: SOL.

=172.- Ranunculus repens Linn. Solda da terra. Lus. [*Ranunculus repens* L. (Ranunculaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Confirmed by J.R. Press, X.1986.

Didynamia

=173.- Lavandula pinnata Mss. Criceta de gallo fig. pict. [*Lavandula pinnata* L.f. (Lamiaceae)]; **Mac.**; **Herb.**: GH (BM000829060); **Other lists**: NPL, SOL; **Notes**: Confirmed by J.R. Press, I.1994.

=174.- Sideritis canariensis Linn. [*Sideritis candicans* Aiton (Lamiaceae)]; **Mad.**; **Other lists**: NPL, SOL; **Notes**: Listed as “Sideritis candicans” in SOL.

=175.- Mentha pulegium Linn. Poejo Lus. [*Mentha pulegium* L. (Lamiaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.
=176.- --------- rotundifolia Linn. [*Mentha suaveolens* Ehrh. (Lamiaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, X.1993, for Flora of Madeira.
=177.- Stachys arvensis Linn. [*Stachys arvensis* (L.) L. (Lamiaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Confirmed by J.R. Press, 7.I.1992, for Flora of Madeira.
=178.- Ballota nigra Linn. [*Ballota nigra* L. (Lamiaceae)]; **Nat.**; **Other lists**: NPL, SOL.
=179.- Clinopodium vulgare Linn. [*Clinopodium vulgare* L. (Lamiaceae)]; **Nat.**; **Other lists**: NPL, SOL.

[Page] 8 Plants of Madeira

=180.- Origanum creticum Linn. Ouregas Lus. [*Origanum vulgare* L. subsp. *virens* (Hoffmanns. & Link) Ietsw. (Lamiaceae)]; **Nat.**; SCV; **Other lists**: NPL, SOL.
=181.- *Thymus vulgaris Linn. [*Thymus vulgaris* L. (Lamiaceae)]; **Cult.**; **Other lists**: SOL.
=182.- Melissa calamintha Linn. [*Calamintha nepeta* (L.) Savi subsp. *sylvatica* (Bromf.) R. Morales (Lamiaceae)]; **Nat.**; **Herb.**: GH (BM000778843), SCV; **Other lists**: NPL, SOL; **Notes**: Revised by J.R. Press, I. 1992, for Flora of Madeira and determinated as *C. sylvatica* subsp. *ascendens*.
=183.- Dracocephalum canariense Linn. [*Cedronella canariensis* (L.) Webb & Berthel. (Lamiaceae)]; **Mac.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.
=184.- *Ocymum Basilicum Linn. [*Ocimum basilicum* L. (Lamiaceae)]; **Cult.**; **Other lists**: SOL.
=185.- Prunella vulgaris Linn. [*Prunella vulgaris* L. (Lamiaceae)]; **Nat.**; **Other lists**: NPL, SOL.
=186.- Antirrhinum cordatum Mss fig. pict. Orelhas de gato Lus. [*Kickxia elatine* (L.) Dumort. (Scrophulariaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.
=187.- Scrophularia scorodonia Linn. [*Scrophularia scorodonia* L. (Scrophulariaceae)]; **Nat.**; GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised by Vilhem Dalgaard, 1979.
=188.- Digitalis purpurea Linn. Tegeira Lus. [*Digitalis purpurea* L. (Scrophulariaceae)]; **Nat.**; **Other lists**: NPL, SOL.
=189.- *Bignonia radicans Linn. [*Campsis radicans* (L.) Seem. (Bignoniaceae)]; **Cult.**; **Other lists**: SOL.
=190.- Acanthus spinosus Linn. [*Acanthus mollis* L. (Acanthaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: SOL; **Notes**: Revised for Flora of Madeira, M.J. Short, VI.1990.

Tetradynamia

=191.- *Lepidium sativum Linn. [*Lepidium virginicum* L. (Brassicaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: In the original label *sativum* is crossed and changed into *virginicum*. Revised by M.J. West, XI. 1990, for Flora of Madeira.

=192.- Cochlearia coronopus Linn. [*Lepidium coronopus* (L.) Al-Shehbaz (Brassicaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=193.- Sisymbrium Nasturtium V. Linn. Agriao Lus. [*Rorippa nasturtium-aquaticum* (L.) Hayek (Brassicaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Revised by M.J. West, XII. 1990 for Flora of Madeira.

=194.- Erysimum officinale Linn. [*Sisymbrium officinale* (L.) Scop. (Brassicaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Revised by M.J. Short, IX.1989, for Flora of Madeira.

=195.- *Brassica oleracea Linn. [*Brassica oleracea* L. (Brassicaceae)]; **Cult.**; **Other lists**: NPL, SOL.

=196.- *--------- rapa Linn. [*Brassica rapa* L. (Brassicaceae)]; **Cult.**; **Other lists**: SOL.

=197.- *Sinapis alba Linn. mustarda Lus. [*Sinapis arvensis* L. (Brassicaceae)]; **Cult.**; **Herb.**: GH (BM00056580); **Other lists**: NPL, SOL; **Notes**: Revised by Guy Baillargeon, 1983.

=198.- Isatis tinctoria Linn. [*Isatis tinctoria* L. (Brassicaceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

Monadelphia

=199.- Geranium robertianum Linn. Agulheta Lus. [*Geranium robertianum* L. (Geraniaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=200.- --------- cicutarium Linn. [*Erodium moschatum* (L.) Aiton (Geraniaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by M.J. West, VIII.1990.

=201.- Sida Rhombifolia Linn. Bertonha Lus. [*Sida rhombifolia* L. (Malvaceae)]; **Intr.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=202. --------- [*Sida spinosa* L. (Malvaceae)] **Intr.**; **Herb.:** SCV; **Other lists**: NPL, SOL.

=203.- Malva rotundifolia Linn. Malva Lus. [*Malva sylvestris* L. (Malvaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, VI.1980.

=204.- --------- mauritanica Linn. [*Malva sylvestris* L. (Malvaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Labeled as *Malva mauritiana* by B&S. Determined by J.R. Press, VII.1986.

=205.- *Hibiscus rosa sinensis Linn. [*Hibiscus rosa-sinensis* L. (Malvaceae)]; **Cult.**; **Other lists**: SOL.

DIADELPHIA

=206.- Fumaria officinalis Linn. Molharinha Lus. [*Fumaria muralis* Sond. ex W.D.J. Koch subsp. *muralis* (Fumariaceae)]; **Nat.**; **Other lists**: NPL, SOL; **Notes**: Determined by J. Press, 8.X.1989, for Flora of Madeira.

=207.- Spartium scoparium Linn. [*Cytisus scoparius* (L.) Link subsp. *scoparius* (Fabaceae)]; **Intr.**; GH (BM000056343); **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=208.- Genista canariensis Linn. Piorno Lus. [*Genista tenera* (Murray) Kuntze (Fabaceae)]; **Mad.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: *Genista canariensis* L. (accepted name *Teline canariensis* (L.) Webb & Berthel.), to which Banks referred this specimen, does not occur in Madeira but is morphologically similar.

=209.- *Lupinus albus Linn. [*Lupinus albus* L. subsp. *albus* (Fabaceae)]; **Cult.**; **Other lists**: SOL.

=210.- *Phaseolus vulgaris α Linn. [*Phaseolus vulgaris* L. (Fabaceae)]; **Cult.**; **Other lists**: SOL.

=211.- *--------- β coccineus Linn. [*Phaseolus coccineus* L. (Fabaceae)]; **Cult.**; **Other lists**: SOL.

=212.- *Pisum sativum Linn. [*Pisum sativum* L. (Fabaceae)]; **Cult.**; **Other lists**: SOL.

=213.- Vicia gracilis Mss. [*Vicia articulata* Hornm. (Fabaceae)]; **Nat.**; **Herb.**: GH (BM000829338); **Other lists**: NPL, SOL; **Notes**: According to Lowe (1868) it refers to *Ervum pubescens* DC. (=*Vicia pubescens* (DC.) Link).

=214.- Ervum hirsutum Linn. Ervilhata Lus. [*Vicia hirsuta* (L.) Gray (Fabaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=215.- Cicer arietinum Linn. [*Cicer arietinum* L. (Fabaceae)]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL.

=216- Ornithopus perpusillus Linn. [*Ornithopus pinnatus* (Mill.) Druce. (Fabaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised by N.J. Turland, X.1993.

=217.- Scorpiurus vermiculata Linn. [*Scorpiurus vermiculatus* L. (Fabaceae)]; **Nat.**; **Other lists**: SOL.

=218.- Psoralea bituminosa Linn. Fudigocos Lus. [*Bituminaria bituminosa* (L.) C.H. Stirton]; **Nat.**; **Herb.**: GH (BM000828994); **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=219.- --------- americana Linn. [*Cullen americanum* (L.) Rydb. (Fabaceae)]; **Intr.**; **Herb.**: GH (BM000838996); **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=220.- Trifolium glomeratum Linn. [*Trifolium glomeratum* L. (Fabaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=221.- Trifolium agrarium Linn. [*Trifolium dubium* Sibth. (Fabaceae)]; **Nat.**; **Herb.**: GH (BM000056746), SCV; **Other lists**: NPL, SOL; **Notes**: Determined by R.J. Press, II.1987, for Flora of Madeira.

=222.- --------- repens Linn. [*Trifolium repens* L. (Fabaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Confirmed by J.R. Press, III.1987, for Flora of Madeira.

=223.- --------- Melilotus Italica Linn. [*Melilotus elegans* Salzm. ex Ser. (Fabaceae)]; **Intr.**; **Other lists**: NPL, SOL.

=224.- --------- angustifolium Linn. Pesegaja Lus. [*Trifolium angustifolium* L. (Fabaceae)]; **Nat.**; **Herb.**: GH (BM000829021), SCV; **Other lists**: NPL, SOL; **Notes**: Confirmed by R.J. Press, II.1987, for Flora of Madeira.

=225.- Lotus glaucus Mscr. fig. pict. [*Lotus glaucus* Aiton (Fabaceae)]; **Mad.**; **Herb.**: GH (BM00050789), SCV; **Other lists**: NPL, SOL; **Notes**: Determined by J.H. Kirkbride Jr., 2006.

=226.- Medicago polymorpha muricata Linn. [*Medicago polymorpha* L. (Fabaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=227.- --------- lupulina Linn. [*Medicago lupulina* L. (Fabaceae)]; **Nat.**; **Other lists**: NPL, SOL.

Polyadelphia

=228.- *Citrus medica Linn. [*Citrus medica* L. (Rutaceae)]; **Cult.**; **Other lists**: SOL.

=229.- --------- Aurantium Linn. [*Citrus x aurantium* L. (Rutaceae)]; **Cult.**; **Other lists**: SOL.

=230.- Hypericum canariense Linn. Sepiao Lus. [*Hypericum canariense* L. (Hypericaceae)]; **Mac.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by N.K.B. Robson, 1980.

=231.- --------- perforatum Linn. peseguiero Lus. [*Hypericum perforatum* L. (Hypericaceae)]; **Nat.**; GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by N.K.B. Robson as var. *veronense* (Scrank) H. Lindb., 1998.

=232.- --------- humifusum Linn. [*Hypericum humifusum* L. (Hypericaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by N.K.B. Robson, 2007.

=233.- --------- glandulosum Mscr. [*Hypericum glandulosum* Aiton (Hypericaceae)]; **Mac.**; **Herb.**: GH (BM000617916); **Other lists**: NPL, SOL; **Notes**: Determined by N.K.B. Robson, 1996.

=234.- --------- evectum Mscr. [*Hypericum grandifolium* Choisy (Hypericaceae)]; **Mac.**; **Herb.**: GH (BM000829215, BM0001024250); **Other lists**: NPL, SOL; **Notes**: Determinated by N.K.B. Robson, 1981.

[Page] 10 Plants of Madera

Syngenesia

=235.- Picris Echioides Linn. Rapasaya Lus. [*Helminthotheca echioides* (L.) Holub (Asteraceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, V.1990, for Flora of Madeira.

=236.- Sonchus oleraceus Linn. Peseguiro Lus. [*Sonchus asper* (L.) Hill (Asteraceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=237.-Lactuca sativa Linn. [*Lactuca sativa* L. (Asteraceae)]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=238.- Leontodon nudicaule Mss. Letubra Lus. [*Leontodon taraxacoides* (Vill.) Mérat (Asteraceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determinated by J.R. Press, IV.1990.

=239.- Crepis tenuifolia Mss. [*Tolpis succulenta* (Aiton) Lowe (Asteraceae)]; **Mac.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised by C.E. Jarvis.

=240.- Lapsana stellata Linn. [*Rhagadiolus stellatus* (L.) Gaertn. (Asteraceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by P.D. Sell, 1972.

=241.- Cicoreum Intybus Linn. [*Cichorium endivia* L. subsp. *divaricatum* (Schousb.) P.D.Sell (Asteraceae)]; **Nat.**; **Herb.**: GH (BM000017576); **Other lists**: NPL, SOL.

=242.- Scolymus hispanicus Linn. [*Scolymus maculatus* L. (Asteraceae)]; **Nat.**; **Other lists**: NPL, SOL.

=243.- Arctium Lappa Linn. [*Arctium minus* (Hill.) Bernh. (Asteraceae)]; **Intr.**; **Other lists**: SOL.

=244.- Carduus pycnocephalus Linn. [*Galactites tomentosa* Moench (Asteraceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL; **Notes**: Specimen in SCV labeled *Carduus pycnocephalus* corresponds to *Galactites tomentosa*. Not revised for Flora of Madeira.

=245.- Carthamus tinctorius Linn. Cardo brabo Lus. [*Carthamus tinctorius* L. (Asteraceae)]; **Intr.**; **Other lists**: NPL, SOL.

=246.- Carthamus lanatus Linn. [*Carthamus lanatus* L. subsp. *lanatus* (Asteraceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Aprovavit J.R. Press, 1991.

=247.- Gnaphalium crassifolium Mss [crossed] fig. pict. [*Helichrysum obconicum* DC. (Asteraceae)]; **Mad.**; **Herb.**: GH (BM000829047, BM00829048), SCV; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, IX.1994, for Flora of Madeira.

=248.- --------- luteoalbidum Linn. [*Pseudognaphalium luteoalbum* (L.) Hilliard & B.L. Burtt (Asteraceae)]; **Nat.**; **Herb.**: GH (BM000829049), SCV; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, V.1991.

=249.- Conyza Saxatilis Linn. Murnaneira Lus. [*Phagnalon saxatile* (L.) Cass. (Asteraceae)]; **Herb.**: GH, SCV; **Nat.**; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, I.1990.

=250.- Erigeron canadense Linn. [*Conyza canadensis* (L.) Cronquist (Asteraceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, I.1990.

=251.- Senecio viscosus Linn. [*Senecio lividus* L. (Asteraceae)]; **Nat.**; **Herb.**: GH (BM000829050, BM000829051), SCV; **Other lists**: NPL, SOL; **Notes**: Determined by J.W. Kadereit, 17.VIII.1982.

=252.- *Aster chinensis Linn. [*Callistephus chinensis* (L.) Nees. (Asteraceae)]; **Cult.**; **Other lists**: SOL.

=253.- *Tagetes erecta Linn. [*Tagetes erecta* L. (Asteraceae)]; **Cult.**; **Other lists**: SOL.

=254.- Chrysanthemum segetum Linn. [*Glebionis segetum* (L.) Fourr. (Asteraceae)]; **Intr.**; **Other lists**: SOL.

=255.- Matricaria parthenium Linn. Artemigo Lus. [*Tanacetum parthenium* (L.) Sch.Bip. (Asteraceae)]; **Intr.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, 21.XI.1988, for Flora of Madeira.
=256.- Anthemis cotula Linn. [*Anthemis cotula* L. (Asteraceae)]; **Intr.**; **Other lists**: NPL, SOL.
=257.- *Helianthus annuus Linn. [*Helianthus annuus* L. (Asteraceae)]; **Cult.**; **Other lists**: SOL.
=258.- Coreopsis Leucanthema Linn. Malpica / Don Andrera Lus. [*Bidens pilosa* L. var. *radiata* (Sch.Bip.) Sherff (Asteraceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by T.G.J. Raynaer, 1983.
=259.- Centaurea calcitrapa Linn. [*Centaurea calcitrapa* L. (Asteraceae)]; **Nat.**; **Herb.**: GH (BM000847062); **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, III.1991.
=260.- Calendula arvensis Linn. [*Calendula arvensis* L. (Asteraceae)]; **Nat.**; **Other lists**: NPL, SOL.
=261.- Lobelia Longifolia Mscr. [*Legousia scabra* (Lowe) Gamisans (Campanulaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL.

[Page] 11 Plants of Madeira

=262.- Viola odorata Linn. Viola Lus. [*Viola odorata* L. (Violaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised for Flora of Madeira by M.J. Short, II.1990.
=263.- *Impatiens balsamina Linn. [*Impatiens balsamina* L. (Balsaminaceae)]; **Intr.**; **Other lists**: SOL.

Gynandria

=264.- Passiflora quadrangularis Linn. [*Passiflora quadrangularis* L. (Passifloraceae)]; **Intr.**; **Other lists**: SOL; **Notes**: cultivated species with edible fruits.
=265.- *Arum colocasia Linn. Inhame Lus. [*Colocasia esculenta* (L.) Schott (Araceae)]; **Intr.**; GH; **Other lists**: NPL, SOL; **Notes**: Determined by E.W. Groves, VI.1972.
=266.- --------- sagittifolium Linn. [*Arum italicum* Mill. subsp. *canariense* (Webb & Berthel.) P.C.Boyce (Araceae)]; **Mac.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by N.J. Turland, XII.1993.
=267.- --------- pictum Mss Inhame de Bresil Lus. fig. pict. [*Caladium picturatum* K. Koch & C.D. Bouché (Araceae)]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL.

Monoecia

=268.- Lemna minor Linn. [*Lemna minor* L. (Lemnaceae)]; **Nat.**; **Other lists**: SOL.
=269.- Zea Mays Linn. [*Zea mays* L. (Poaceae)]; **Cult.**; **Other lists**: SOL.
=270.- Coix Lacryma Jobi Linn. Conteiras brancas Lus. [*Coix lacryma-jobi* L. (Poaceae)]; **Cult.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Confirmed by T.A. Cope, 7.XI.1988.

=271.- Carex muricata Linn. [*Carex divulsa* Stokes subsp. *divulsa* (Cyperaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by Rene David, 15.IV.1993.

=272.- *Buxus sempervirens Linn. [*Buxus sempervirens* L. (Buxaceae)]; **Cult.**; **Other lists**: SOL.

=273.- Urtica urens Linn. [*Urtica membranacea* Savigny (Urticaceae)]; **Nat.**; **Herb.**: GH (BM000072973); **Other lists**: NPL, SOL; **Notes**: Determined by J.R. Press, 24.II.1987, for Flora of Madeira.

=274.- *Morus nigra Linn. [*Morus nigra* L. (Moraceae)]; **Cult.**; **Other lists**: SOL.

=275.- Amaranthtus hybridus Linn. [*Amaranthus hybridus* L. (Amaranthaceae)]; **Intr.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=276.- --------- blitum Linn. Bredos Lus. [*Amaranthus blitum* L. (Amaranthaceae)]; **Nat.**; **Herb.**: GH (BM000083055), SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=277.- Poterium sanguisorba Linn. [*Sanguisorba verrucosa* (Link ex G.Don) Ces. (Rosaceae)]; **Nat.**; **Herb.**: GH (BM000035955); **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira. This is a sterile specimen.

=278.- Juglans regia Linn. [*Juglans regia* L. (Juglandaceae)]; **Cult.**; **Other lists**: SOL.

=279.- Fagus castanea Linn. [*Castanea sativa* Mill. (Fagaceae)]; **Intr.**; **Other lists**: SOL.

=280.- Pinus pinea Linn. Pinheira. [*Pinus pinaster* Aiton. (Pinaceae)]; **Intr..**; **Herb.**: GH; **Other lists**: NPL, SOL.

=281.- *Cupressus sempervirens Linn. [*Cupressus sempervirens* L. (Cupressaceae)]; **Cult.**; **Other lists**: SOL.

=282.- *Cucurbita lagenaria Linn. [*Lagenaria siceraria* (Molina) Standl. (Cucurbitaceae)]; **Cult.**; **Other lists**: SOL.

=283.- *--------- pepo Linn. [*Cucurbita pepo* L. (Cucurbitaceae)]; **Cult.**; **Other lists**: SOL.

=284.- *--------- citrullus Linn. [*Citrullus lanatus* (Thunb.) Matsum. & Nakai (Cucurbitaceae)]; **Cult.**; **Other lists**: SOL.

=285- *Cucumis Melo Linn. [*Cucumis melo* L. (Cucurbitaceae)]; **Intr.**; **Other lists**: SOL.

=286.- *--------- Sativus Linn. [*Cucumis sativus* L. (Cucurbitaceae)]; **Intr.**; **Other lists**: SOL.

[Page] 12 Plants of Madera

Dioecia

=287.- Salix purpurea Linn. Vime Lus. [*Salix x rubens* Schrank (Salicaceae)]; **Cult.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by R.J. Press, I.1991,

=288.- --------- Helix Linn. Seiseiro Lus. [*Salix x rubens* Schrank (Salicaceae); vime, seixo]; **Cult.**; **Herb.**: GH; **Other lists**: NPL, SOL.

=289.- Smilax latifolia Mss Alegacadela Lus. fig. pict. [*Smilax pendulina* Lowe (Smilacaceae)]; **Mad.**; **Herb.**: GH (BM001009926, BM001009927), SCV;

Other lists: NPL, SOL; **Notes**: Determined as *Smilax aspera* by A.R. Vickery, 6.X.1989.

=290.- Populus alba Linn. Alamo Lus. [*Populus alba* L. (Salicaceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=291.- Mercurialis ambigua Linn. [*Mercurialis annua* L. (Euphorbiaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determinated by J.R. Press, VII.1986, for Flora of Madeira.

=292.- *Carica Papya Linn. [*Carica papaya* L. (Caricaceae)]; **Cult.**; **Other lists**: SOL.

=293.- Juniperus oxycedrus Linn. [*Juniperus cedrus* Webb & Berthel. subsp. *maderensis* Rivas Mart. et al. (Cupressaceae)]; **Mad.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by R.J. Press, II.1991.

=294.- Taxus baccata Linn. [*Taxus baccata* L. (Taxaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Aprovavit R.J. Press, 1991.

=295.- *Ruscus androgynus Linn. Alegacam Lus. [*Semele androgyna* (L.) Kunth (Liliaceae)]; **Mac.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by A.R. Vickery, 5.VI.1989.

Polygamia

=296.- Musa sapientium Linn. [*Musa acuminata* Colla (Musaceae)]; **Cult.**; **Other lists**: SOL.

=297.- Andropogon hirtum Linn. [*Hyparrhenia hirta* (L.) Stapf (Poaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by O.S.

=298.- Holcus halepensis Linn. Scalracha Lus. [*Sorghum halepense* (L.) Pers. (Poaceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=299.- --------- mollis Linn. [*Holcus lanatus* L. (Poaceae)]; **Intr.**; **Herb.**: GH (BM000643301), SCV; **Other lists**: NPL, SOL; **Notes**: In original label: "Madera locis saxosis prope Funchal 14 Sept.1768". Determined by T.A. Cope, 13.IV.1989.

=300.- Cenchrus setosus Mscr. [*Cenchrus ciliaris* L. (Poaceae)]; **Intr.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Determined by T.A Cope, 18.V.1988, for Flora of Madeira.

=301.- Parietaria officinalis Linn. Alfavaca Lus. [*Parietaria judaica* L. (Urticaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: The sheet also appears to have a specimen of *P. officinalis* L. determinated by J.R. Press which probably is not from Madeira.

=302.- *Mimosa Farnesiana Linn. [*Acacia farnesiana* (L.) Willd. (Fabaceae)]; **Intr.**; **Other lists**: SOL.

=303.- *Diospyrus Lotus Linn. Fig. Fuit. [*Diospyros lotus* L. (Ebenaceae)]; **Cult.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=304.- *Ficus carica Linn. [*Ficus carica* L. (Moraceae)]; **Cult.**; **Other lists**: SOL.

Cryptogamia

=305.- Equisetum arvense Linn. [*Equisetum arvense* L. (Equisetaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL.

=306.- +Osmunda Maderensis Mscr. fig. pict. [*Pteris incompleta* Cav. (Pteridaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised for Flora of Madeira.

=307.- --------- spicant Linn. [*Struthiopteris spicant* (L.) F.W.Weiss. (Blechnaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Revised for Flora of Madeira.

=308.- Pteris aquilina Linn. Feiteira Lus. [*Pteridium aquilinum* (L.) Kuhn (Hypolepidaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=309.- Asplenium adiantum nigrum Linn. [*Asplenium adiantum-nigrum* L. (Aspleniaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=310.- --------- marinum Linn. [*Asplenium marinum* L. (Aspleniaceae)]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=311.- --------- monanthes Linn. fig. pict. [*Asplenium monanthes* L. (Aspleniaceae)]; **Nat.**; **Other lists**: NPL, SOL.

[Page] 13 Plants of Madeira

=312.- Polypodium Thelypteris Mscr. Acrostichum Th. Linn. fig. pict. [*Christella dentata* (Forssk.) Brownsey & Jermy (Thelypteridaceae)]; **Nat.**; GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised for Flora of Madeira.

=313.- --------- lineatum Mscr. [*Asplenium billotii* F.W. Schultz (Aspleniaceae)]; **Nat.; Herb.**: SCV; **Other lists**: NPL, SOL.

=314.- --------- fragile Linn. [*Cystopteris viridula* (Desv.) Desv. (Woodsiaceae)]; **Nat.**; **Herb.**: GH; **Other lists**: NPL, SOL; **Notes**: Determined by Mary Gibby, 3.II.1989, as *C. diaphana* (Bory) Blasdell. Revised for Flora of Madeira.

=315.- Adiantum trapeziforme Linn. Cabreira Lus. [*Adiantum capillus-veneris* L. (Adiantaceae);]; **Nat.**; **Herb.**: SCV; **Other lists**: NPL, SOL.

=316.- Trichomanes canariense Linn. [*Davallia canariensis* (L.) Sm. (Davalliaceae)]; **Nat.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised for Flora of Madeira.

=317.- Mnium politrichoides Linn. [*Mnium* sp. (Mniaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=318.- Hypnum rugosum Mscr. [*Hypnum* sp. (Hypnaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=319.- Jungermannia tamariscifolia Linn. [*Frullania tamarisci* (L.) Dumort. (Jubulaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=320.- Lichen articulatus Linn. Barba Lus. [*Usnea articulata* (L.) Hoffm. (Parmeliaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=321.- --------- calicaris Linn. [*Ramalina calicaris* (L.) Fr. (Ramalinaceae); liquen]; **Nat.**; **Other lists**: NPL, SOL.

=322.- --------- digitatus Linn. [*Cladonia digitata* (L.) Hoffm. (Cladoniaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=323.- Marchantia polymorpha Linn. Patinha Lus. [*Marchantia polymorpha* L. (Marchantiaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=324.- Lichen geographicus Linn. [*Rhizocarpon geographicum* (L.) DC. (Rhizocarpaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=325.- --------- calicaris Linn. [*Ramalina calicaris* (L.) Fr. (Ramalinaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=326.- Byssus aurea Linn. [*Trentepohlia aurea* (L.) Mart. (Trentepohliaceae)]; **Nat.**; **Other lists**: NPL, SOL.

=327.- Phoenix dactyfera Linn. [*Phoenix dactylifera* L. (Arecaceae)]; **Intr.**; **Other lists**: SOL; **Notes**: During Banks and Solander's visit to Madeira the Canary Island palm (*P. canariensis* H. Wildpret) was not recognized as a distinct species. We cannot rule out that this record refers to this Canary Island endemic.

Appendix

=328.- Faya Lus. [*Morella faya* (Aiton) Wilbur (Myricaceae)]; **Mac.**; **Herb.**: GH, SCV; **Other lists**: NPL, SOL; **Notes**: Revised by M.J. Short, VI.1986, for Flora of Madeira.

=329.- Pao branco Lus. [*Picconia excelsa* (Aiton) DC. (Oleaceae)]; **Mac.**; **Herb.**: SCV; **Other lists**: NPL, SOL; **Notes**: Not revised for Flora of Madeira.

=330.- Salvia major folio glauco serrate. Sloane Hist. Jam. Pag. 17. T.3 fig.3 [*Teucrium betonicifolium* Jacq. (Lamiaceae)]; **Mad.**; **Herb.**: GH (BM001025250), SCV; **Other lists**: NPL, SOL; **Notes**: Species listed as *T. betonicum* L'Hér. by Press and Short (1994), Jardim and Menezes de Sequeira (2008), and Menezes de Sequeira et al. (2012), see details regarding this name in article by Francisco-Ortega et al. (2020). Not revised for Flora of Madeira.

Herbarium specimens without matching entries in Bank's journal

For the seven species listed below we located herbarium specimens, but they do not correspond to material recorded in Banks's journal list. Only one of these species, the Madeiran endemic *Bystropogum punctatus*, was recorded in the two other studied documents.

Bystropogon punctatus L'Hér. (Lamiaceae); **Mad.**; **Herb.**: GH; **Other lists**: NPL, SOL.

Galium parisiense L. (Rubiaceae); **Nat.**; **Herb.**: GH (BM000829003); **Notes**: See entry 49 for further details about this species and this specimen.

Isolepis cernua (Vahl) Roem. & Schult. (Cyperaceae); **Nat.**; **Herb.**: GH.

Plantago coronopus L. (Plantaginaceae); **Nat.**; **Herb.**: GH. Not revised for Flora of Madeira.

Plantago maritima L. (Plantaginaceae); **Nat.**; **Herb.**: GH; **Notes**: This species is not listed by Press and Short (1994), Jardim and Menezes de Sequeira (2008) or Menezes de Sequeira et al. (2012). Not revised for Flora of Madeira.

Rumex cf. *crispus* L. (Polygonaceae); **Intr.**; **Herb.**: GH.

Tolpis barbata (L.) Gaertn. (Asteraceae); **Nat.**; **Herb.**: GH.

VI. CONCLUDING REMARKS

Our study of Banks and Solander's collections and records from Madeira stem from three documents found in two different countries: Australia and the United Kingdom. These documents are very similar in their content, but because they had different scopes there are differences among them. Solander's *Primitiae Florae Maderensis* aimed to provide a tentative flora for the island and includes both plant records from Cook's expedition and a list of Madeiran taxa previously published by the pre-Linnean naturalists Leonard Plukenet and Hans Sloane (Francisco-Ortega et al., 1994; Menezes de Sequeira et al. 2010). The second of these documents, the inventory of specimens placed inside the drying books, only provides an index of the collected herbarium material. It includes details on the number of duplicate collections as well as information on the location of specimens inside the drying books. The third document is part of Banks's journal and it is the only one housed in Australia. This manuscript lists all plants that were recorded in Madeira.

Regarding the BM herbarium specimens, they are found in three different sets, namely: the BM general herbarium, one of the expedition's drying book (Madeira III bundle), and one of the bounded volumes of the BM historical collections that contains specimens collected during the voyage.

When the available information and material found in these three different documents and herbarium holdings is analyzed together we found that Banks's collections from Madeira comprised 334 records for 328 taxa. Twenty of these taxa are Madeiran endemics, 19 are Macaronesian endemics, 156 are non-endemic natives, 67 are introduced, and 72 are cultivated. Among them, 305 taxa are spermatophyte, twelve are ferns, two are mosses, two are liverworts, one is an alga, five are lichens, and one is a fungus. Regarding the herbarium material there are 210 collections for 206 taxa, 16 of these taxa are Madeiran endemics, 18 are Macaronesian endemics, 100 are non-endemic natives, 60 are introduced, and 12 are cultivated. These specimens account for ten fern and 196 spermatophyte taxa; and Banks and Solander primarily focused on collecting natives - both endemics and non-endemics.

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AUTHOR'S CONTRIBUTION

Botanical history review: ASG, JFO, MAC
Location and taxonomic identification of relevant herbarium specimens: ASG, MAC
First draft: ASG, JFO
Review and edition of the final draft: all authors.

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APPENDIX 1

Accepted names are printed in bold. Names as they were written in Banks's list (Banks's journal housed in State Library of New South Wales, Australia) are printed in regular font.

Name	Entry number
___Acacia farnesiana___ __(L.) Willd.__	302
___Acanthus mollis___ __L.__	190
Acanthus spinosus Linn.	190
Achyranthes aspera Sicula Linn.	87
___Achyranthes sicula___ __(L.) All.__	87
Acrostichum Th. Linn.	312
___Adiantum capillus-veneris___ __L.__	315
Adiantum trapeziforme Linn.	315
*___Agave americana___ __L.__§	110
*___Agrimonia eupatoria___ __L.__	143
Agrostis bromoides Linn.	26
Agrostis linearis Mscr.	25
Agrostis pallida Mscr...	28
Agrostis sanguinalis Mscr.	27
___Agrostis___ __sp.__	25
Agrostis sylvatica Linn.	29
___Aichryson divaricatum___ __(Aiton) Praeger__	147
*___Allium cepa___ __L.__	106
___Allium dentiferum___ __Webb & Berthel.__	105
Allium oleraceum Linn.	105
Aloe perfoliata Linn.	109
___Aloe vera___ __(L.) Burm.f.__	109
Alsine media Linn.	101
Alypum angustifolium Mscr.	47
*___Amaranthus blitum___ __L.__	276
*___Amaranthus hybridus___ __L.__	275
*___Amaryllis belladonna___ __L.__	104
*___Ammi majus___ __L.__	95
___Ammi visnaga___ __(L.) Lam.__	94
Amomun Zingiber Linn.	2

Notes to the Taxonomic Index:

* Taxon for which the accepted name matches that written in Banks's journal list or Solander's flora.

§ Name reported in Banks's journal list either (i) is a slight orthographical variant of the accepted scientific name (ii) has the specific epithet in upper case or (iii) has an authority does not match that of the accepted scientific name.

¥ Banks's journal list only reports the generic name.

‡ Name reported in Banks's journal list with the codes "Mscr." or "Mss." These names were considered new taxa by Banks and Solander.

† Refers to Thomas Heberden.

¶ Species for which there is herbarium material.

NA refers to species for which there is herbarium material but it was not recorded in Banks's journal list nor in Solander's unpublished *Primitiae Florae Maderensis, sive catalogus Plantarum in Insula Madera*.

NPL refers to species listed in the index to the contents of the drying books but not recorded in Banks's journal list.

SOL refers to species listed in Solander's flora but not recorded in Banks's journal list.

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Informe del proceso editorial de la revista *Scientia Insularum 3* (2020)

El equipo de dirección se reunió en las primeras quincenas de los meses de mayo y julio y en las segundas quincenas de septiembre y noviembre de 2020 para tomar decisiones sobre el proceso editorial del número 3 de la revista. El tiempo medio transcurrido entre la recepción, evaluación, aceptación, edición e impresión final de los trabajos fue de 24 meses.

Estadística:
N.º de trabajos recibidos en *Scientia Insularum*: 11.
N.º de trabajos aceptados para publicación: 11 (100%). Rechazados: 0 (0%).
Media de revisores por artículo: 2.
Media de tiempo entre envío y aceptación: 4,5 meses.
Media de tiempo entre aceptación y publicación: 5,5 meses.

Los revisores varían en cada número, de acuerdo con los temas presentados.

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