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Bryophytes from Glaziou's historical collections: revisiting the flora of Rio de Janeiro and implications for conservation

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ABSTRACT

Auguste Glaziou went to Brazil in 1858 at the invitation of Emperor D. Pedro II where he worked as director of the Imperial House of Parks and Gardens in the city of Rio de Janeiro until 1897. He is considered one of the greatest plant collectors of Brazil and collected numerous bryophytes. The bryoflora of the state of Rio de Janeiro is one of the richest in the country, but also includes the highest number of threatened species. Glaziou collected in Rio de Janeiro where the coverage of the Atlantic Forest suffered a great reduction and loss of biodiversity. The objectives of this work are to analyze the species registered by Glaziou, assess what percentage of the bryoflora was sampled at that time, re-collect and evaluate the conservation status of the species. Our results show that 86% of the species collected by Glaziou have been collected in the state Rio de Janeiro. 4% percent have been collected in the last 60 years, 10% has not been found in the last 100 years and two species remain only known from the original Glaziou collection (= type). Our fieldwork recorded 35% of the species in their original sites. Eighteen species are considered threatened taxa in the state of Rio de Janeiro, including 16 species that are critically threatened (CR), two threatened (EN), three of little concern (LC) and one of insufficient data (DD).

KEY WORDS

Historic collections,
recollecting species,
Atlantic Forest,
threatened bryophytes.

RÉSUMÉ

Bryophytes des collections historiques de Glaziou : revisiter la flore de Rio de Janeiro et ses implications pour la conservation.

Auguste Glaziou est arrivé au Brésil à l'invitation de l'empereur Dom Pedro II, où il a été directeur de la Maison impériale des parcs et jardins de la ville de Rio de Janeiro. Il est considéré comme l'un des plus grands collectionneurs de plantes de l'histoire brésilienne avec une grande contribution principalement en bryologie. La bryoflore de l'État de Rio de Janeiro est l'une des plus riches du pays, mais elle est en tête de la liste des espèces végétales menacées. Glaziou a collecté à Rio de Janeiro où la couverture de la forêt atlantique a subi une réduction et une perte de biodiversité. Les objectifs de ce travail sont d'analyser les espèces enregistrées par Glaziou, d'évaluer quel pourcentage de la bryoflore a été échantillonné à ce moment-là, de collecter à nouveau et d'évaluer l'état de conservation de l'espèce. Nos résultats ont montré que 86% de la liste originale de Glaziou avait déjà été collectée à Rio de Janeiro. 4% de cette liste a été collectée au cours des 60 dernières années, 10% n'a pas été trouvée au cours des 100 dernières années et deux espèces sont signalées uniquement via le matériel type de la collection de Glaziou. Dans ce travail de terrain, 35% des espèces ont été trouvées dans les sites d'origine. 18 espèces ont été considérées comme présentant un certain degré de menace pour l'État, une espèce avec des données insuffisantes (DD), deux espèces menacées (EN), 16 espèces en danger critique d'extinction (CR) et trois espèces peu préoccupantes (LC).

MOTS CLÉS

Collections historiques, rappel d'espèces, forêt atlantique, bryophytes menacés.

INTRODUCTION

Auguste François Marie Glaziou was born in Lannion, Bretagne (France) in 1828 and studied botany in Paris at the Muséum national d'Histoire naturelle. Dom Pedro II, the Brazilian Emperor, invited him in 1858 to work in Brazil as director of the Imperial House of Parks and Gardens in Rio de Janeiro city, where he resided until his return to France in 1897 (Santos 2016). During this time, he carried out much fieldwork and collaborated in expeditions in the states of Brazil. Glaziou is considered one of the greatest plant collectors in the Brazilian history, especially of Rio de Janeiro state (Stafleu & Cowan 1979), who made a great contribution in bryology (Costa *et al.* 2016). However, Glaziou never worked with bryophytes he was a collector of plants in general, and the bryophyte identifications were made by specialists in Europe, in particular Émile Bescherelle at the Paris museum (PC), and his greatest interest was in the use plants economic.

During his time in Brazil, 22 790 specimens of plants were recorded in his field notebook, including more than 2500 bryophytes, collected in different parts of the country either by himself or by countless contributors, of which about 700 were described as new to science (<http://glaziou.cria.org.br/>; Santos 2016).

Bryophytes were sampled in Rio de Janeiro state in “Serra dos Órgãos” (Barcia *et al.* 1980) where “Raiz da Serra” is located (currently “Vila Inhomirim»), “Serra da Estrela”; “Fazenda da Mandioca” (owned by Baron of Langsdorff), “Porto Estrela” and “Tinguá”; in addition in Serra da Mantiqueira in Itatiaia National Park, at the border with the states of São Paulo and Minas Gerais.

The Serra dos Órgãos region is located in the Atlantic Forest and it is one of the areas with greatest diversity in the Atlantic Forest biome with a large variety of habitats and high species richness, including several endemics (Velooso &

Góes Filho 1982; Costa *et al.* 2009; Coelho *et al.* 2017). The area was explored by many botanists such as C.F.P. Von Martius (1794-1868), G. Gardner (1812-1849), G.H. Von Langsdorff (1774-1852), E.H.G. Ule (1854-1915), L. Riedel (1790-1861), F.C. Hoehne (1882-1959), and A.C. Brade (1881-1971) (Vellozo 1825; Bediaga & Lima 2015; Coelho *et al.* 2017). The first naturalist to study the bryophytes of Brazil, G. Raddi (1817-1818), had also visited this region with the Spix & Martius expedition (1817-1823) (Rizzini 1954; Costa 2009).

The bryophyte flora of the Rio de Janeiro state is recognized as one of the richest in the country, with around 900 species, of which 47 are found only in the state and 12 are endemic (Costa & Peralta 2015; Coelho *et al.* 2017), with 125 vulnerable species (VU), 25 threatened (EN) and 147 with deficient data (DD). Among the species considered Least Concern (LC), many are dependent on the conservation of their habitats (Costa *et al.* 2005). Itatiaia and Serra dos Órgãos have the largest number of endemic taxa (Costa *et al.* 2005). Rio de Janeiro state leads the list of vascular plant species at risk of extinction in Brazil, being one of the states with the highest number of threatened species, or with interest for conservation and research (Martinelli & Moraes 2013). In addition, this state counts more than 100 species of plants among those that are not threatened, but with interest for conservation or research (Martinelli & Moraes 2013). About 97% of the surface of the state was originally covered by Atlantic Forest; currently only 19% remains (Fundação S.O.S. Mata Atlântica 2019). Habitat loss and degradation are serious threats to bryophytes worldwide (Hallinbäck & Hodgetts 2000), since the species are extremely sensitive to environmental disturbances (Vanderpoorten & Hallinbäck 2008). Still, this state together with that of São Paulo holds the greatest richness of bryophytes in Brazil (<http://floradobrasil.jbrj.gov.br>).

TABLE 1. — List of repatriated Glaziou species. (*, endemic to Brazil; **, within Brazil only known from the Atlantic Forest; ***, within Brazil only known from the state of Rio de Janeiro).

DIVISION/Family/Species	Voucher	DIVISION/Family/Species	Voucher
MARCHANTIOPHYTA		Pallavicinaceae	
Aneuraceae		** *** <i>Jensenia spinosa</i> (Lindenb. & Gottsche) Grolle	PC0741586
<i>Riccardia digitiloba</i> (Spruce ex Steph.) Pagán	PC0741583	<i>Symphogyna brasiliensis</i> (Nees) Mont.	PC0741589
** <i>Riccardia fucoidea</i> (Sw.) Schiffn.	PC0741579	<i>Symphogyna brongniartii</i> Mont.	PC0741538
<i>Riccardia glaziovii</i> (Spruce) Meenks	PC0741587	** <i>Symphogyna podophylla</i> (Thumb.) Mont. & Nees	PC0741507
<i>Riccardia regnellii</i> (Åongstr.) Hell	PC0741581	Pelliaceae	
Balantiopsidaceae		<i>Noteroclada confluens</i> Taylor ex Hook.f. & Wilson	PC0741542
** <i>Isotachis aubertii</i> (Schwaegr.) Mitt.	PC0741585	Plagiochilaceae	
Cephaloziaceae		** *** <i>Plagiochila boryana</i> Gottsche & Steph.	PC0741533
<i>Odontoschisma variable</i> (Lindenb. & Gottsche) Trevis.	PC0741543	** <i>Plagiochila crispabilis</i> Lindenb.	PC9741643
Chonecoleaceae		<i>Plagiochila corrugata</i> (Nees) Nees & Mont.	PC0741633
<i>Chonecolea doellingeri</i> (Nees) Grolle	PC0741546	<i>Plagiochila montagnei</i> Nees	PC0741634
Fossombroniaceae		<i>Plagiochila raddiana</i> Lindenb.	PC0741547
<i>Fossombronia porphyrorhiza</i> (Nees) Prosk.	PC0741588	<i>Plagiochila rutilans</i> Lindenb.	PC0741525
Frullaniaceae		Porellaceae	
<i>Frullania atrata</i> (Sw.) Nees	PC0741493	<i>Porella brasiliensis</i> (Raddi) Schiffn.	PC0741598
<i>Frullania brasiliensis</i> Raddi	PC0741497	<i>Porella swartziana</i> (Weber) Trevis.	PC0741602
<i>Frullania riojaneirensis</i> (Raddi) Åongstr.	PC0741515	Radulaceae	
Herbetaceae		** <i>Radula nudicaulis</i> Steph.	PC0741611
<i>Herbertus juniperoideus</i> ssp. bivittatus (Spruce) Feldberg & Heinrichs	PC0741614	<i>Radula recubans</i> Tayl.	PC0741607
Jungermanniaceae		<i>Radula stenocalyx</i> Mont.	PC0741603
** <i>Anastrophyllum tubulosum</i> (Nees) Grolle	PC0741632	Ricciaceae	
Lejeuneaceae		<i>Riccia stenophylla</i> Steph.	PC0741350
<i>Bryopteris diffusa</i> (Sw.) Nees	PC0741686	<i>Ricciocarpos natans</i> (L.) Corda	PC0741312
<i>Bryopteris filicina</i> (Sw.) Nees	PC0741548	Trichocoleaceae	
<i>Cheilolejeunea filiformis</i> (Sw.) W. Ye, R.L. Zhu & Gradst.	PC0741698	** <i>Leiomitra brevifissa</i> (Steph.) T. Katag	PC0741613
<i>Cheilolejeunea trifaria</i> (Mont.) R.M.Schust.	PC0741504	BRYOPHYTE	
<i>Coleolejeunea obliqua</i> (Nees & Mont.) Schiffn.	PC0741675	Andreaeaceae	
<i>Diplasiolejeunea brunnea</i> Steph.	PC0741645	<i>Andreaea microphylla</i> Müll.Hal.	PC0738932
** *** <i>Drepanolejeunea aculeata</i> Bischl.	PC0741671	Bartramiaceae	
<i>Drepanolejeunea mosenii</i> (Steph.) Bischl.	PC0741667	** <i>Breutelia grandis</i> (Hampe) Paris	PC0741459
<i>Lejeunea aphanes</i> Spruce	PC0741685	** <i>Breutelia subtomentosa</i> (Hampe) A.Jaeger	PC0709350
<i>Lejeunea cerina</i> (Lehm. & Lindenb.) Lehm. & Lindenb.	PC0741706	<i>Philonotis hastata</i> (Duby) Wijk & Marg.	PC0709366
<i>Lejeunea flava</i> (Sw.) Nees	PC0741526	** <i>Philonotis longiseta</i> (Michx.) Britt.	PC0709369
<i>Lejeunea glaucescens</i> Gottsche	PC0741704	<i>Philonotis uncinata</i> (Schwägr.) Brid.	PC0709368
<i>Lejeunea grossitexta</i> (Steph.) M.E.Reiner & Goda	PC0741692	Brachytheciaceae	
** <i>Lejeunea laeta</i> (Lehm.) Lehm. & Lindenb.	PC0741705	<i>Eurhynchium clinocarpum</i> (Taylor) Paris	PC0741292
<i>Lejeunea laetevirens</i> Nees & Mont.	PC0741705	<i>Helicodontium capillare</i> (Hedw.) A.Jaeger	PC0709637
<i>Lejeunea phyllobola</i> Nees & Mont.	PC0741516	<i>Meteoridium remotifolium</i> (Müll.Hal.) Manuel	PC0709561
<i>Lejeunea pterigonia</i> (Lehm. & Lindenb.) Mont.	PC0741523	<i>Platyhypnidium aquaticum</i> (A.Jaeger) M.Fleisch.	PC0709785
<i>Lejeunea trinitensis</i> Lindenb.	PC0741514	** <i>Rhynchostegium scariosum</i> (Taylor) A.Jaeger	PC0709602
<i>Leptolejeunea elliptica</i> (Lehm. & Lindenb.) Schiffn.	PC0741661	Bryaceae	
** <i>Lepidolejeunea eluta</i> (Nees) R.M.Schust.	PC0741506	<i>Bryum argenteum</i> Hedw.	PC0709486
<i>Lepidolejeunea involuta</i> (Gottsche) Grolle	PC0741629	<i>Bryum limbatum</i> Müll.Hal.	PC0709465
<i>Lopholejeunea nigricans</i> (Lindenb.) Schiffn.	PC0741702	<i>Bryum subapiculatum</i> Hampe	PC0709487
<i>Odontolejeunea lunulata</i> (Weber) Schiffn.	PC0741657	<i>Rhodobryum beyrichianum</i> (Hornsch.) Müll.Hal.	PC0709482
<i>Schiffneriolejeunea polycarpa</i> (Nees) Gradst.	PC0741697	<i>Rosulabryum billarderi</i> (Schwägr.) J.R.Spence	PC0709458
Lepidoziaceae		<i>Rosulabryum capillare</i> (Hedw.) J. R. Spence	PC0709483
<i>Bazzania gracilis</i> (Hampe & Gottsche) Steph.	PC0741521	<i>Rosulabryum densifolium</i> (Brid.) Ochrya	PC0709453
<i>Bazzania hookeri</i> (Lindenb.) Trevis.	PC0741618	Bruchiaceae	
<i>Bazzania stolonifera</i> (Sw.) Trevis.	PC0741529	<i>Trematodon longicollis</i> Michx.	PC0709276
<i>Kurzia capillaris</i> (Sw.) Grolle	PC0741621	** <i>Trematodon vaginatus</i> Müll. Hal.	PC0709272
** <i>Lepidozia cupressina</i> (Sw.) Nees	PC0741536	Calymperaceae	
** <i>Lepidozia inaequalis</i> Steph.	PC0741537	<i>Syrrhopodon gaudichaudii</i> Mont.	PC0709659
* <i>Micropterygium pterygophyllum</i> (Nees) Trevis.	PC0741615	<i>Syrrhopodon prolifer</i> Schwägr.	PC0709189
Lophocoleaceae		Daltoniaceae	
<i>Cryptolophocolea martiana</i> (Nees) L.Söderstr., Crand.-Stötl. & Stotler	PC0741624	<i>Eriopus flexicaulis</i> (Hampe) Paris	PC0709587
** <i>Lophocolea muricata</i> (Lehm.) Nees	PC0741625	Dicranaceae	
Marchantiaceae		<i>Dicranella hilariana</i> (Mont.) Mitt.	PC0709287
<i>Dumortiera hirsuta</i> (Sw.) Nees	PC0741485	<i>Dicranella lindigiana</i> (Hampe) Mitt.	PC0709263
Metzgeriaceae		<i>Holomitrium crispulum</i> Mart.	PC0709319
<i>Metzgeria albinea</i> Spruce	PC0721818	Ditrichaceae	
** <i>Metzgeria brasiliensis</i> Schiffn.	PC0741570	** <i>Ceratodon stenocarpus</i> Bruch & Schimp. ex Müll.	PC0709282
** <i>Metzgeria convoluta</i> Steph.	PC0741555	Hal	
** <i>Metzgeria cratoneura</i> Schiffn.	PC0741578	Entodontaceae	
<i>Metzgeria dichotoma</i> (Sw.) Nees	PC0741554	<i>Entodon hampeanus</i> Müll. Hal.	PC0709605
		<i>Entodon serrulatus</i> Mitt.	PC0709613
		<i>Erythrodonium longisetum</i> (Hook.) Paris	PC0709623

TABLE 1. — Continuation.

DIVISION/Family/Species	Voucher	DIVISION/Family/Species	Voucher
Fabroniaceae		Polytrichaceae	
<i>Dimerodontium mendozense</i> Mitt.	PC0709630	<i>Pogonatum pensilvanicum</i> (E.B.Bartram ex Hedw.) P.Beauv.	PC0709532
<i>Fabronia ciliaris</i> (Brid.) Brid.	PC0709572	** <i>Polytrichadelphus pseudopolytrichum</i> (Raddi) G.L.Smith	PC0709525
Fissidentaceae		* <i>Polytrichum angustifolium</i> Hedw.	PC0741528
<i>Fissidens elegans</i> Brid.	PC0709650	<i>Polytrichum juniperinum</i> Hedw.	PC0709528
Funariaceae		Pottiaceae	
<i>Funaria calvescens</i> Schwägr.	PC0738926	<i>Hyophila involuta</i> (Hook.) A. Jaeger	PC0709178
Hypnaceae		<i>Hyophila laetevirens</i> Broth.	PC0709175
<i>Chryso-hypnum elegantulum</i> (Hook.) Hampe	PC0741250	<i>Leptodontium viticulosoides</i> (P.Beauv.) Wijk & Margad.	PC0709391
<i>Ectropothecium leptochaeton</i> (Schwägr.) W.R.Buck	PC0709780		
<i>Mittenothamnium reptans</i> (Hedw.) Cardot	PC0709585	<i>Tortella humilis</i> (Hedw.) Jenn.	PC0709222
<i>Vesicularia vesicularis</i> (Schwägr.) Broth.	PC0709729	<i>Weissia breutelii</i> Müll.Hal.	PC0709283
Lembophylaceae		Pylaisiadelphaceae	
** <i>Orthostichella pachygastrella</i> (Müll. Hal. ex Ångstr.) B.H.Allen & Magill	PC0741450	<i>Isopterygium brachyneuron</i> (Müll.Hal.) Mitt.	PC0721603
<i>Orthostichella versicolor</i> (Mull.Hal.) B.H.Allen & W.R.Buck	PC0741452	<i>Isopterygium subbrevisetum</i> (Hampe) Broth.	PC0709603
Leucobryaceae		<i>Isopterygium tenerifolium</i> (Hedw.) Mitt.	PC0146575
<i>Campylopus arctocarpus</i> (Hornsch.) Mitt.	PC0741922	<i>Isopterygium tenerum</i> (Sw.) Mitt.	PC0709180
<i>Campylopus cryptopodioides</i> Broth.	PC0741463	Racopilaceae	
<i>Campylopus filifolius</i> (Hornsch.) Mitt.	PC0709305	<i>Racopilum tomentosum</i> (Hedw.) Brid.	PC0738418
<i>Campylopus griseus</i> (Hornsch.) A.Jaeger	PC0741928	Rhacocarpaceae	
* <i>Leucobryum clavatum</i> Hampe	PC0709245	** <i>Rhacocarpus inermis</i> (Müll. Hal.) Lindb.	PC0709537
<i>Leucobryum crispum</i> Müll.Hal.	PC0709234	Rhizogoniaceae	
<i>Leucobryum albicans</i> (Schwägr.) Lindb.	PC0709244	<i>Hymenodon aeruginosus</i> (Hook.f. & Wilson) Müll.Hal.	PC0709786
<i>Octoblepharum albidum</i> Hedw.	PC0709232	<i>Pyrrhobryum spiniforme</i> (Hedw.) Mitt.	PC0741458
Leskeaceae		Rigodiaceae	
<i>Haplocladium microphyllum</i> (Hedw.) Broth.	PC0709777	<i>Rigodium toxarion</i> (Schwägr.) A.Jaeger	PC0709587
Meteoriaceae		Sematophyllaceae	
** <i>Meteorium nigrescens</i> (Hedw.) Dozy & Molk.	PC0709547	<i>Acroporium caespitosum</i> (Hedw.) W.R.Buck	PC0709792
Mniaceae		<i>Aptychopsis pyrrophylla</i> (Müll.Hal.) Wijk & Marg.	PC0146561
<i>Plagiomnium rhynchophorum</i> (Hook.) T.J.Kop.	PC0709498	* <i>Brittonodoxa subpinnata</i> (Brid.) W.R.Buck, P.E.A.S.Câmara & Carv.-Silva	PC0709638
Orthotrichaceae		** <i>Microcalpe subsimplex</i> (Hedw.) Mitt.	PC0709714
*** <i>Macrocoma brasiliense</i> (Mitt.) Vitt.	PC0709376	** <i>Sematophyllum beyrichii</i> (Hornsch.) Broth.	PC0709814
** <i>Macrocoma orthotrichoides</i> (Raddi) Wijk & Marg.	PC0709402	*** <i>Sematophyllum decumbens</i> Mitt.	PC0709809
<i>Macromitrium richardii</i> Schwägr.	PC0709373	* <i>Sematophyllum oedophysidium</i> W.R.Buck	PC0146562
<i>Schlotheimia capillaris</i> Hampe	PC0741476	** <i>Trichosteleum glaziovii</i> (Hampe)W.R. Buck	PC0741254
<i>Schlotheimia jamesonii</i> (Arn.) Brid.	PC0709436	* <i>Vitalia galipensis</i> (Müll.Hal.) P.E.A.S.Câmara, Carv.-Silva & W.R.Buck	PC0709748
<i>Schlotheimia rugifolia</i> (Hook.) Schwägr.	PC0709425	Stereophyllaceae	
<i>Schlotheimia torquata</i> (Sw. ex Hedw.) Brid.	PC0709415	<i>Pilosium chlorophyllum</i> (Hornsch.) Müll.Hal.	PC0741273
Pilotrichaceae		Sphagnaceae	
<i>Callicostella rufescens</i> (Mitt.) A. Jaeger.	PC0741272	<i>Sphagnum recurvum</i> P. Beauv.	PC0741894
** <i>Hypnella pilifera</i> (Hook.f. & Wilson) A. Jaeger	PC0709692	ANTHOCEROTOPHYTA	
** <i>Lepidopilum longifolium</i> Hampe	PC0709586	Dendrocerotaceae	
<i>Thamniopsis incurva</i> (Hornsch.) W.R.Buck	PC0709660	** <i>Nothoceros vicentianus</i> (Lehm. & Lindenb.) J.C.Villarreal	PC0741524
** <i>Lepidopilum subsubulatum</i> Geh. & Hampe	PC0721349	Phymatocerotaceae	
** <i>Thamniopsis langsdorffii</i> (Hook.) W.R.Buck	PC0709676	<i>Phymatoceros bulbiculosus</i> (Broth.) Stotler, W.T.Doyle & Crand.-Stotl.	PC0741530
<i>Thamniopsis undata</i> (Hedw.) W.R.Buck	PC0709666		
** <i>Trachyxiphium aduncum</i> (Mitt.) W.R.Buck	PC0709675		
<i>Trachyxiphium saxicola</i> (R.S.Williams) Vaz-Imbassahy & D.P.Costa	PC0709753		

When Glaziou collected in Rio de Janeiro state, the area was still largely covered by Atlantic Forest, making its collections extremely important for historic bryophyte knowledge. Part of the areas in which Glaziou collected have been replaced by farming (annual and perennial crops), silviculture and urban areas, and abundance and distribution of the species must over time have been affected by the habitat modifications. However, comparisons of the long-term changes in species diversity are not available. Comparative studies of vegetation over time are essential to identify and understand changes in vegetation and their broader impacts on local biodiversity, in addition to being necessary for the application of effective conservation and management practices.

The bryophytes collected by Glaziou in Brazil were sent to the herbarium of Paris (PC) and studied by Émile Bescherelle (1828-1903), who made duplicates for his private collection and also sent of the mosses to Ernst Hampe (1795-1880) and of the liverworts to Stephani (1842-1927) in Germany. After the deaths of Hampe and Stephani the Natural History Museum, London (BM) as well as the herbarium of Geneva (G) respectively acquired their collections. The same happened with the Bescherelle herbarium after his death, so that the two duplicate sets prepared by Bescherelle ended up in BM. Many of his collections are also housed in Museu Nacional do Rio de Janeiro, Brazil (R) (Costa *et al.* 2016). The collections in PC fortunately have been made available with pictures

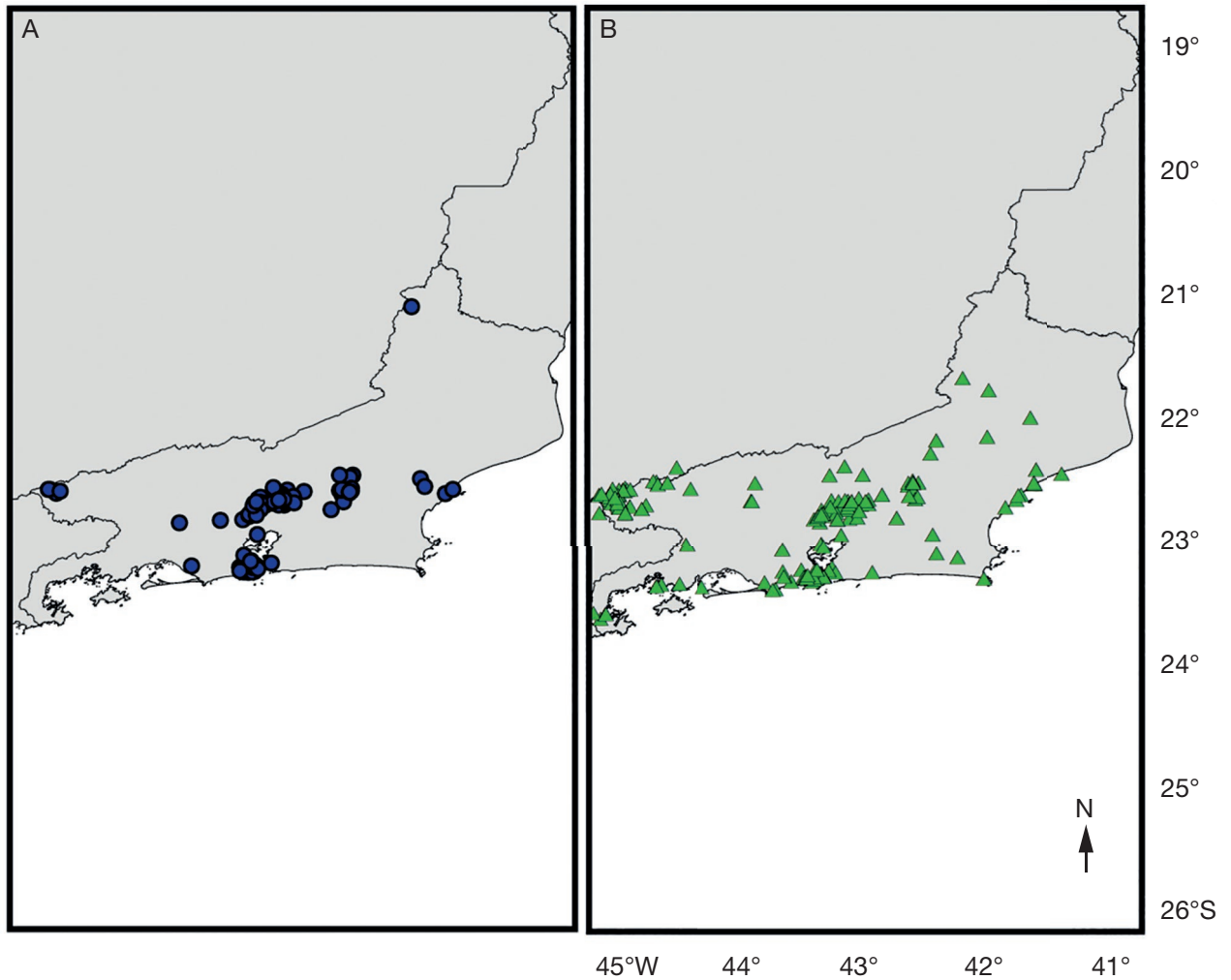


FIG. 1. — Localities of the collections of Glaziou made in the state of Rio de Janeiro (A) and of other collectors (B).

and determinations as part of the REFLORA project (<http://glaziou.cria.org.br>). The objectives of this study are to analyze the species collected by Glaziou, assess what percentage of the actual bryoflora was sampled at that time, re-collect and evaluate the conservation status of the species recollected.

MATERIAL AND METHODS

SAMPLING AND FIELD WORK

Specimens collected by Glaziou and kept in BM, LE, PC and R were determined or revised and the label information was used to map the original collection sites as precise as possible (Costa *et al.* 2016). Images of the specimens and labels are available on the website glaziou.splink.org.br. Furthermore, online databases such as Jabot, Flora do Brasil, Virtual Herbarium of Plants and Fungi, and SpeciesLink were consulted. Three ten-day expeditions were carried out trying to recollect the species collected by Glaziou in the state of Rio de Janeiro. Locations visited included Serra dos Órgãos National Park

(municipalities of Guapimirim, Petrópolis and Teresópolis), Serra da Estrela (municipality of Petrópolis), Macaé (municipality of Nova Friburgo), Itatiaia National Park (municipality of Itatiaia) and Tijuca and Corcovado Forest (municipality of Rio de Janeiro) (Fig. 1).

IDENTIFICATION AND DATA ANALYSES

The methodology of collection, herborization and preservation of the material followed Vanderpoorten *et al.* (2010); samples were deposited in UB with duplicates in SP and RB. Specimens were identified with the specific literature and compared with herbarium samples. The classification systems follow Renzaglia *et al.* (2009) for Anthocerotophyta, Crandall-Stotler *et al.* (2009) for Marchantiophyta and Goffinet *et al.* (2009) for Bryophyta. To assess the conservation status of bryophytes in Rio de Janeiro state we followed Hällingbäck & Hodgetts (2000), evaluating only species without new records in the last 50 years at Global Biodiversity Information Facility (GBIF), published papers, herbariums or field observations. GeoCAT (Geospatial

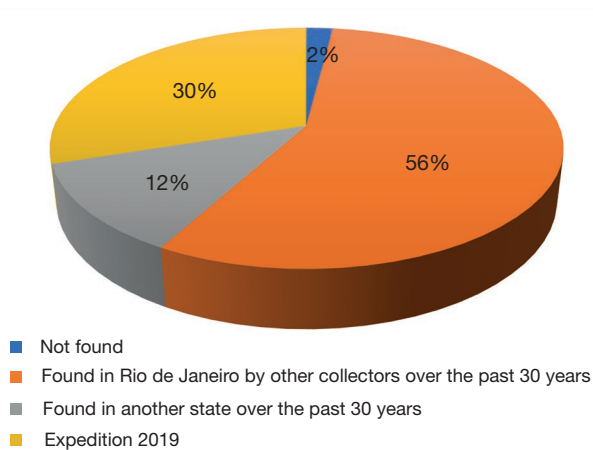


FIG. 2. — Species collected by Glaziou in the state of Rio de Janeiro.

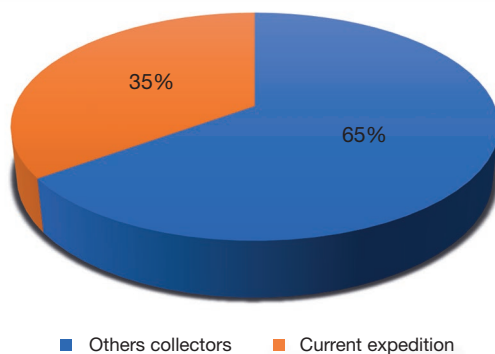


FIG. 3. — Species re-collected in the last 30 years; 35% were made during this study, 56% by other collectors.

Conservation Assessment Tool), was used to facilitate the assessment and analysis (<http://geocat.kew.org/>).

RESULTS

We analyzed *c.* 3000 bryophyte specimens from herbaria and new collections. Of 169 species collected by Glaziou in the state of Rio de Janeiro, 95 (56%) were re-collected by other collectors in the state of Rio de Janeiro during the last 30 years (Fig. 2). Twenty-one species (12%) are not recorded in Rio de Janeiro state but in areas of the Amazon and Cerrado biomes. This makes us believe that these species were erroneously cited by Glaziou for Rio de Janeiro.

In our fieldwork, 51 species (35%) were found, which added to the 95 species (65%) found by other collectors a total of 146 species found in Brazil in the last 30 years, and do not suffer any kind of threat (Fig. 3). In the total of 169 species, 23 remaining species (14%) are considered threatened here, with 7 species (4%) collected only in the last 60 years and 16 species (10%) that have not been found for more than 100 years.

Two species remain only known from the type material collected by Glaziou: *Eriopus flexicaulis* (Hampe) Paris (Daltoniaceae) and *Hyophila laetevirens* Broth. (Pottiaceae). These species have already been evaluated (Costa *et al.* 2016).

The bryophytes collected by Glaziou in the state of Rio de Janeiro have 26 endemic species to Brazil (7%), to the Atlantic Forest (5%) and have not been re-collected for more than 50 years. Eighteen of them are considered threatened: one with insufficient data (DD), two endangered (EN), 16 critically endangered (CR) and three little concerned (LC) (Table 2).

DISCUSSION

Auguste Glaziou made a major contribution to the study of botany with a large number of important historical floristics records for the state in locations that today have been modified by population growth, urbanization and agricultural expansion.

Most bryophyte species recorded by Glaziou are not threatened. Our results provide information about their distribution, ecology, as well as about conservation status, and allows the planning of actions that minimize the impacts that may affect the bryophytes.

Lepidopilum flexicaule Hampe (nowadays *Eriopus flexicaulis*) remains unknown since having been collected by Glaziou and was not taxonomically evaluated since its publication. Churchill (1998) does not include this taxon in the Neotropical revision of *Lepidopilum*, nor it is included in the Flora do Brazil online (<http://floradobrasil.jbrj.gov.br>). Taxonomic revisions are extremely important for our knowledge of organisms, their geographic distribution and conservation status.

Hyophila laetevirens was collected by Glaziou in 1878 on Corcovado hill and was described by Brotherus (1849-1929) in 1895; the lectotype is in PC and a duplicate is in BM according with Costa *et al.* (2016).

The re-collection of bryophyte species collected by Glaziou has mainly been done in the last forty years. By the end of the 1970s, only about 10 species listed by Glaziou had been re-collected, probably because most botanists in Brazil had worked on vascular plants, and there were only very few bryophyte specialists.

The number of bryophyte species indicated here as threatened are associated with forest remains in the State and emphasize the needs of updating the State's list of endangered species. In addition, data inconsistencies within the official List of Species of the Endangered Flora for the state of Rio de Janeiro resulted in the occasional use of ancillary lists, such as those published for the other states and other biomes from Brazil, therefore, we consider all the essential lists of bryophytes in Rio de Janeiro.

The assessment of the conservation status of bryophyte species in the state showed that the categories indicated as threatened have a restricted area of occupation, with few localities of occurrence. The state of Rio de Janeiro presents an expressive contribution of great richness and diversity of Brazilian bryophytes, mainly related to its interior of the Atlantic Forest ecosystem. The threatened species indicated

TABLE 2. — Conservation status of threatened bryophyte species of the state of Rio de Janeiro treated in this paper.

Taxon	Status	Criteria
<i>Bazzania gracilis</i> (Hampe & Gottsche) Steph.	CR	C2b
<i>Cryptolophocolea martiana</i> (Nees) L.Söderstr., Crand.-Stotl. & Stotler	EN	C2b
<i>Drepanolejeunea aculeata</i> Bischler	CR	B1, 2abcd
<i>Entodon serrulatus</i> Mitt.	CR	C1
<i>Eriopus flexicaulis</i> (Hampe) Paris	DD	DD
<i>Fissidens elegans</i> Brid.	LC	none
<i>Lejeunea aphanes</i> Spruce	CR	C2b
<i>Lepidolejeune eluta</i> (Nees) R.M.Schust.	CR	B1, 2abcd
<i>Metzgeria albinea</i> Spruce	CR	B1, 2abcd
<i>Metzgeria brasiliensis</i> Schiffn.	LC	none
<i>Metzgeria convoluta</i> Steph.	CR	C2b
<i>Metzgeria cratoneura</i> Schiffn.	CR	C2b
<i>Micropterygium pterygophyllum</i> (Nees) Trevis.	CR	B1, 2abcd
<i>Odontoschisma variabile</i> (Lindenb. & Gottsche) Trevis.	CR	C2b
<i>Philonotis longiseta</i> (Michx.) Britt.	CR	C2b
<i>Phymatoceros bulbiculosus</i> (Broth.) Stotler, W.T.Doyle & Crand.-Stotl.	CR	B1, 2abcd
<i>Platyhypnidium aquaticum</i> (A.Jaeger) M.Fleisch.	EN	C2b
<i>Ricciocarpos natans</i> (L.) Corda	LC	none
<i>Sematophyllum decumbens</i> Mitt.	CR	C1
<i>Sematophyllum oedophysidium</i> W.R.Buck	CR	C2b
<i>Trachyxiphium saxicola</i> (R.S.Williams) Vaz-Imbassahy & D.P.Costa	CR	C1
<i>Trematodon vaginatus</i> Müll.Hal.	CR	C2b

here presents their geographic distribution well represented in Conservation Units. Among the fully protected Conservation Units with the largest number of endemic flora species in the state of Rio de Janeiro, the Serra dos Órgãos National Park, Tijuca National Park and Itatiaia National Park stand out.

The increasing number of specimens to the present day shows an advance in science as the technologies used in botany studies increase, especially in the group of bryophytes, as well as the training of specialists from the years 80's of the 20th century. This data set of the research shows that the biodiversity in the places of the collection areas by the naturalist did not suffer relevant impacts. Since, most species were found in regions that today are in Conservation Units areas. These areas are fully protected and have the function of ensuring the representativeness of significant and ecologically viable samples from the different populations, habitats and ecosystems of the national territory, preserving the existing biological heritage (MMA 2019). In addition, they guarantee traditional populations the sustainable use of natural resources in a rational way and still provide the surrounding communities with the development of sustainable economic activities (MMA 2019).

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