RAPP | Revisão Anual de Patologia de Plantas

doi: 10.31976/0104-038321v280004 SEÇÃO 1

EXPLORING THE OVERLOOKED DIVERSITY OF PLANT-ASSOCIATED CERRADO MICROFUNGI

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ABSTRACT

In this review, we present an historic account of the work on the diversity of fungi associated with plants of the Cerrado Biome, including an overview of the studies carried out by the research group of the Mycological Collection connected to the Herbarium UB (Universidade de Brasília), and the rust fungi in Herbarium IBI (Instituto Biológico, São Paulo). The contributions to Cerrado mycology from the early 19th century to the present days were highlighted. Illustrative maps were included to show the geographical distribution of the main fungal groups, associated with native plants of the Cerrado, belonging to the five predominant orders: Pucciniales (rust fungi), Phyllachorales (tar-spot fungi), Capnodiales (cercosporoid fungi: Family Mycosphaerellaceae), as well as Meliolales and Asterinales (black mildews).

KEYWORDS: black mildews-Asterinales and Meliolales, cercosporoid fungi-Mycosphaerellales, Neotropical microfungi, rust fungi-Pucciniales, tar-spot fungi-Phyllachorales

INTRODUCTION

The aim of this publication was to present and analyze data on plant-associated microfungi from Brazilian Cerrado, gathered in the Mycological Collection of Herbarium UB (Universidade de Brasília) (MCHUB) from 1993 until 2021, and the rust fungi in Herbarium IBI (Instituto Biológico de São Paulo), collected in three reserves belonging to the State of São Paulo (Mogi Guaçu, Mogi Mirim, and Antônio Carlos).

The MCHUB inventory resulted from a series of expeditions to all core states where the Cerrado biome predominates. Most of the field work was financed by a US$ 260,000.00 grant to the Universidade de Brasília by the Fundação Banco do Brasil, which also covered costs of the physical infrastructure of the Collection. Those expeditions starting in 1994 were responsible for the inclusion of over 85% of all fungi presently deposited in the MCHUB. Extensive exploration included the main Cerrado official reserves, mainly the National Parks in Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, and Distrito Federal, where detailed surveys of plant-associated microfungi were for the first time the object of work by Brazilian mycologists. The result was the *ex situ* preservation of almost 25,000 exsiccates containing an average of two fungal species each, representing about 50,000 different fungi on

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herborized plant material preserved in envelopes measuring 30 x 20 cm. This large volume of material allows for the subsampling of each exsiccate to study the different fungi found in each one. The collection inventory includes among members of the kingdom Fungi, some saprotrophic Agaricomycetes (Agaricales, Boletales, Cantharellales, Corticiales, Geastrales, Hymenochaetales, Polyporales, Russulales) that make up mere 311 exsiccates, out of a total of 24,572. However, the focus of the MCHUB are the microscopic fungi associated with the leaves and branches of the native plants from Cerrado, which include epiphytes, parasites, and hyperparasites. These microfungi are distributed in phylum Ascomycota among 7 classes, 42 orders and 47 families, and for the phylum Basidiomycota in 8 classes, 11 orders, and 27 families. Among microfungi belonging to Ascomycota and Basidiomycota a total of 744 genera are represented in the MCHUB, with a total of 642 identified at the species level. The inventory is in a dynamic phase where there is material available and space for additional taxonomical effort.

This publication will reveal the result reached up to now, that include collections from 1991 until 2021, at the main body of the Cerrado biome. However, the Cerrado in the State of São Paulo and the Cerrado islands of the State of Roraima were not exploited by the MCHUB expeditions, and unfortunately regions in the States of Piaui and Tocantins presently remains subsampled. However, the important data on rust fungi (Pucciniales) from São Paulo, contributed by Carvalho-Junior et al. (2008), was included in our analyses. It is not our objective to review all the mycological studies and taxonomical novelties revealed by the work at the MCHUB, but simply list the available information, review historical aspects of the Cerrado mycology, and show the geographical distribution of the predominant microfungal groups found in the Cerrado. These main groups are mostly biotrophic, host specific plant parasites, and will be threatened with extinction whenever this happens to their plant hosts.

THE CERRADO

The Cerrado is a Neotropical savanna that occupies about 2 million km^2, or 22% of the Brazilian territory, and is in the heart of South America. Among Brazilian biomes, the Cerrado is second in extension, smaller only than the Amazonian biome, and extends over the states of Bahia, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Maranhão, Piauí, São Paulo, Tocantins, Federal District, with large islands of vegetation in Roraima (CAVALCANTI & JOLY 2002). Additionally, it encroaches into the neighboring countries, Bolivia, and Paraguay (VELAZCO 2018), where a fungal collection effort was never performed and is badly needed. Furthermore, Velazco (2018) argued that the highest plant species richness and rarity are found in the central part of the Brazilian Cerrado, which is, at the same time, the most disturbed region. However, Bolivia is the second country showing large undisturbed areas with high species richness and rarity, mainly associated with the Cerrado and the Chiquitana Dry Forest. In Paraguay, plant species richness and rarity were concentrated mainly in the northern part of the Chaco Humido and Chaco Seco. These are two countries where a collaborative effort is needed to begin exploring fungal diversity in substantial fraction of the Cerrado biome outside of the Brazilian frontiers.

The Brazilian Cerrado has over 12,000 known plant species, of which 44% are endemic (SCARIOT et al. 2005, MENDONÇA et al. 2008, MARTINELLI & MORAES 2013), and 645 species are critically endangered. This represents more than 30% of the species that are on the red list of threatened species in Brazil (MARTINELLI & MORAES 2013). Almost all Brazilian herbaceous plants or herbs occur in this region (SCARIOT et al. 2005). Furthermore, Lima (2011) showed that the headwaters of the biome contribute to feed eight of the 12 Brazilian hydrographic regions as defined by the National Water Agency – ANA. Consequently, the importance of the biome to maintain the country's water resources is significant. Giulietti et al. (2009) list 2,291 species of species of rare plants in Brazil, meaning that around 7% of our flora is rare, the majority of which is concentrated in Cerrado areas. In Brazil, there are more than 43,000 indigenous vascular plants (GIULIETTI et al. 2005, 2009). Considering a global flora of *ca* 380,000 species, about 14 to 15% of world plant diversity is present in Brazil (PATON et al., 2008). Expansion of modern agriculture, bad management of the tropical forests, and deforestation in areas where endemism occurs in high levels, led to the establishment of thirty-five global biodiversity hotspots, two of them in Brazil, Cerrado and Atlantic Forest hotspots (MITTERMEIER et al. 1998, MYERS et al. 2000, STRASSBURG et al. 2017), with endemism estimated in 4,400 species for the Cerrado, and 8,000

for the Atlantic Forest. Many of the plant associated microfungi are mostly parasitic and thus depend on their host to survive. Thus, whenever a plant enters the list of endangered species a set of microfungi are also at risk of extinction. It was shown that over ten fungal species can be associated with each plant species in the Cerrado (DIANESE 2000). Thus, just in the case of the 4,400 endemic species, we estimated an associated mycota containing over 40,000 fungal species. As just around 1,000 such fungi were reported from the Cerrado, it is clear the need to accelerate efforts on *ex situ* conservation through the implementation of stable culture collections to preserve those culturable species growing on Cerrado plants. This is a basic step and a great challenge if we want to explore our mycodiversity for the benefit of the country and the world. However, before that we need to identify our microfungi taking them out of their generalized anonymity, we need to name them. This is where MCHUB contributes with Cerrado mycology by practicing a taxonomical work with credibility, as recognized internationally. Finally, the continuous use of the phylogenetic species concept for the identification of every specimen studied, maintaining the continuity of field work to obtain fresh material, and an effort to expand the culture collection, will ensure future academic growth for the MCHUB.

A BRIEF HISTORY OF CERRADO MYCOLOGY

During the ninth Century, there were practically no mycological studies carried out by Brazilians in Brazil. However, contributions to the knowledge of the Brazilian fungi started with works by European mycologists focusing macromycetes. Fidalgo (1968) highlighted important contributions starting with Link (1809) recording six species of basidiomycetes from Brazil. The Rev. Miles Joseph Berkeley published a series from 1844 to 1856, designated as Decades of Fungi, that included descriptions of fungi from South America, namely from Peru, and Rio Negro in Brazil (PEGLER 1996).

Berkeley (1843) covered a wide group of macromycetes from Brazil provided by the Scottish medical doctor and important plant collector George Gardner, who lived in Brazil from 1836 to 1841 (GARDNER 1849). Gardner collected extensively along the coastal areas of the Brazilian Atlantic Forest, with a few specimens of fungi from the States of Goiás and Minas Gerais where Cerrado vegetation predominates (GARDNER 1840). Among ascomycetes, only a sooty mold (*Antennaria pannosa*) was described, and *Cladosporium herbarium* listed (BERKELEY 1843). Later, Berkeley & Cooke (1877) reported that 437 species of mostly macromycetes were known from Brazil, including 356 Hymenomycetes, 55 Ascomycetes and 13 Gasteromycetes. Berkeley (1879) reported on 81 species collected by the French botanist A.F.M. Glaziou (FUNDAÇÃO CASA DE RUI BARBOSA 2021) from the Atlantic Forest at Rio de Janeiro. Cooke (1892) described a few ascomycetes on plants and plant debris from Brazil (*Helotiella stromatica* (=*Puttemansia stromatica*, *Dothidella bambusae* (=*Rhopographus bambusae*), *Clypeolum dissiliens* (=*Schizopeltis dissiliens*), and *Metasphaeria pusilla*).

A historical highlight was the arrival of Carlos Luiz Spegazzini (*1858-†1926) in Argentina in 1879, an Italian immigrant who became the most important Latin American mycologist, as shown by Farr (1973). He collected, described, and established the first collection of microfungi of South America, that remains as the most important today, followed by those established much later by Ahmés Pinto Viégas in the 40ies, and Augusto Chaves Batista starting in 1951. Most fungi from Brazil studied by Spegazzini, were obtained by the Catalan collector Puiggari from the Atlantic Forest in Apiaí, State of São Paulo (SPEGAZZINI 1881abcd, 1889), and by Alfred Usteri (GLOBAL PLANTS 2021), a Swiss botanist who spent part of his life also in São Paulo, including for the first time areas covered by the Brazilian Cerrado. Spegazzini (1908), working with Usteri's collections, established important ascomycete genera (e.g. *Dimerosporiella, Dimeriella, Eudarluca, Hyalotheles,* and *Phaeoseptoria*), including some hyperparasites (species of *Dimerosporium, Dimeriella, Eudarluca, Lonchospermella, Zukalia*), six new *Cercospora* species, four new *Phyllachora*, four new *Septoria* species, and two new *Meliola* species.

However, the plant-associated Cerrado mycobiota remained practically unexplored, and had its most definitive beginning with the works by Paul Christopher Hennings (*1841-†1918), an eminent German mycologist working at the Herbarium Berolinense, firmely connected in Brazil through the German botanist naturalized Brazilian Ernst H. G. Ule (GLOBAL PLANTS 2021). Working with Ule collections from 1883 to 1912, Hennings studied the mycobiota associated with primeval Cerrado

vegetation present in the States of São Paulo (HENNINGS 1896), Goiás (HENNINGS 1895), Mato Grosso (HENNINGS 1900), Minas Gerais (HENNINGS 1896). Hennings (1902ab, 1904ab, 1908) was also supplied with important collections by the Belgian Brazilian plant-pathologist Arsènne Putemans (PATRIMÔNIO BELGA NO BRASIL 2021). Putemans deserves also to be remembered as the first collector to put together a fungarium in Brazil, today located at Herbarium of the Universidade Federal Rural do Rio de Janeiro - UFRRJ, presently curated by Prof. Carlos A. Inacio (NYBG STEERE HERBARIUM 2021).

Paul C. Hennings gave a relevant contribution to the early knowledge of the Cerrado microfungi from 1895 to 1908, predominantly from areas in the State of Goiás, with a few samples from Minas Gerais and São Paulo, describing a total of 143 species in 42 genera of Ascomycota, 6 Pucciniales, and 1 Ustilaginales (*Aposphaeria glaziovii*, *Asterina salaciae*, *Asteroma tecomae*, *Campsotrichum tetracerae, Coniothyrium salaciae*, *Dicoccum glaziovii* ≡ (≡*Septoidium glaziovii*), *Dimerosporium echites* (≡ *Seynesia echites*), *Dothidella glaziovii*, *Excipula ilicicola*, *Helminthosporium tapurae*, *Ophiobolus ingae* (≡ *Diatractium ingae*), *Ophiobolus ingae* (≡ *Diatractium ingae*), *Phloeospora myrtacearum*, *Phoma cocoes*, *Phyllachora ficicola*, *Phyllachora urbaniana*, *Phyllosticta clusiae, Phyllosticta cocoes, Phyllosticta kielmeyerae, Phyllosticta lafoensiae* (≡ *Asteromella lafoensiae*), *Phyllosticta pterandrae* (≡ *Asteromella pterandrae*), *Phyllosticta qualeae* (≡ *Asteromella qualeae*), *Phyllosticta qualeae* (≡ *Asteromella qualeae*), *Placosphaeria cordiae, Placosphaeria salvertiae*, *Placosphaeria smilacis*, *Placosphaeria vochysiae, Septorella salaciae, Septoria symploci*.

In addition, other German Botanist and Mycologist Andreas Allerscher (*1828-†1903) described 30 species of ascomycetes on Cerrado plants, working with collections from the State of Goiás by the French botanist August Glaziou (FUNDAÇÃO CASA DE RUI BARBOSA 2021), a report included in Hennings (1895).

Dietel (1897, 1899) studying Ule´s collections of rust fungi described 70 species from Brazil, however, only six from the Cerrado of Minas Gerais: *Aecidium guatteriae*, *Puccinia circinans* (=*P. arenariae*), *P. velata*, *Uredo alstroemeriae*. *U. uleana*, *Uromyces giganteus* (=*U. brasiliensis*).

Anders Fredrik Regnell (*1807–†1884) a Swedish medical doctor that just after graduation in 1837 in Stockholm, moved to Brazil and settled in the small town of Caldas in the State of Minas Gerais, until his death in 1884. There, besides his excellent medical work, he became a self-taught botanist, and one of the most important plant collectors of the country. He was a highly regarded medical doctor, and had also significant investments in coffee plantations, yielding him a large fortune also as a moneylender, practicing interests of up to 20% a year (SANTOS 2016). He financially supported a group of Swedish botanists and collectors in Brazil, and together they gave an enormous contribution to the study of the Brazilian flora, that included some fungi (CONCHA-QUEZADA 2012). The Royal Swedish Academy of Sciences, in 1870, 14 years before Regnell's death established the Regnellian Herbarium at the Swedish Museum of Natural History to accommodate the Brazilian collection, today with 11,500 plant specimens, containing 7,500 nomenclatural types from Brazil. The Regnellian Fund created with resources originating from the fortune donated by Regnell remains still active (SANTOS 2016).

A few species of rust fungi from the Cerrado in the State of Mato Grosso, collected by Regnell´s partners, C.A.M. Lidman and G.O. Malme, were described by the Swedish mycologist Juel (1897), as follows: *Aecidium calosporum* and *Uromyces foveolatus*, collected by Malme; and *Aecidium mattogrossense, A. momordicae, Leptinia brasiliensis* (type species of *Leptinia*), *Uredo mogiphanis*, based on Lidman´s collections. Later Jørstad (1956) contributed with the descriptions of *Crossopsora angusta, Puccinia callosa,* both holotypes collected by Malme.

Major contributions specifically to the study of Cerrado rust fungi came from the American explorer and banker E. D. W. Holway, who preferentially collected rust fungi extensively in South America during the early 1920´s (ARTHUR 1925). His collections were the raw material for important works published later by H. S. Jackson that included the description of 16 species of Pucciniales from the Cerrado (JACKSON 1926, 1927, 1931abc, 1932).

Thurston-Junior (1940) studied several rust fungi mostly from the Atlantic Forest, but included two new species, *Endophylloides duguetiae*, recognized as *Dietelia duguetiae* by Buriticá & Hennen (1980), and *Uredo cassiae-rugosae*, both from the Cerrado at Uberlândia, Minas Gerais.

In 1912, the French mycologist André Pierre

Jules Maublanc (*1880-†1958) worked with Eugenio dos Santos Rangel (*1877-†1953) at Museu Nacional in Rio de Janeiro (MAUBLANC 1913, MAUBLANC & RANGEL 1915, GRILLO 1935). Rangel (1916a, 1916b, 1918, 1921) became the first native Brazilian to work with taxonomy of microfungi, concentrated mainly in the study of pathogenic fungi on crop plants, and those associated with plants common in both Atlantic Forest and Cerrado, as the case of fungi in *Tabebuia* (=*Handroanthus*) species (RANGEL 1921, DIANESE et al. 1994b).

The two most important Brazilian mycologists, Batista (*1916-†1967) (CARNEIRO 1968, BEZERRA et al. 2017) and Viégas (*1905-†1986) (COSTA 1986) benefitted from the fungal collections of Cerrado microfungi by the pioneer botanist and first Emeritus Professor of the Institute of Biological Sciences of the University of Brasilia, the late Prof. Ezechias Paulo Heringer (*1905-†1987). E. P. Heringer, the founding botanist and ecologist of Brasília, the new Brazilian capital inaugurated in 1960, installed over 1,000 miles inland deep into the Cerrado of Central Brazil. He was responsible for the preservation of almost 60,000 ha of Cerrado when he established the Parque Nacional de Brasília (Brasília National Park), Estação Ecológica de Águas Emendadas, an important ecological reserve, and the area where is today the Jardim Botânico de Brasília (Brasília Botanical Garden). He was honored with a natural reserve (PARQUE ECOLÓGICO EZECHIAS HERINGER 2021) and an Herbarium (JARDIM BOTÂNICO DE BRASÍLIA 2021), both named after him. He was one of the founders of the Sociedade Botânica do Brasil (2021) and its Vice-President in 1978.

After the works by the European and American collectors and mycologists, only by the early 1940´s Viégas (1943, 1944, 1945bcdef, 1946) and Viégas & Teixeira (1945) established a monumental contribution to Brazilian mycology. Viégas studied the cercosporoid fungi (VIÉGAS 1945a), later incorporated in Chupp (1953), and contributed with the description of many other Ascomycetes (VIÉGAS 1944, 1945b, 1946abc; VIÉGAS & CARDOSO 1944) from Brazil. Viégas and collaborators revealed species characteristically associated with hosts endemic or common in the Cerrado, *e.g.*: *Septoidium didymopanacis*, *Septoria cremasti*, *S. lafoensiae, S. siparunae*, *Colletotrichum cecropiae*, *Pestalotia rapanea*, *Cladobotryum australe*, *Passalora eragrostidis*, *Rhinotrichum alterosum*, *Spondylocladium nigerrimum*, *Melanconium nectandrae*, *Patouillardiella copaiferae* (VIÉGAS 1945a, VIÉGAS & TEIXEIRA 1945, VIÉGAS 1947). Viégas (1961) published the historical *Índice dos Fungos da América do Sul,* extremely precise and useful in times that predated internet, digital records and the personal computers. Later he wrote an 890-page dictionary of mycology and plant pathology (VIÉGAS 1979). Importantly, seven years before his retirement, he described the genus *Porotenus*, a member of the Pucciniales from the Cerrado (VIÉGAS 1960), the only genus by a Brazilian mycologist appearing in the second edition of the Illustrated Genera of Rust Fungi (CUMMINS & HIRATSUKA 1983).

Historically, Batista and collaborators gave the most extensive contribution to Brazilian mycology (SILVA & MINTER 1995). Their focus in Cerrado microfungi was entirely dependent on Heringer's fieldwork starting in the mid 1950´s in Paraopeba, Minas Gerais, and after 1960 in the Federal District, during the construction of Brasília. Heringer, besides his botanical and ecological work was an efficient fungal collector in those two distinct areas covered with Cerrado vegetation. In 1951, Batista inaugurated the historical Instituto de Micologia do Recife, where he became the main protagonist of *ca* 700 papers dealing with over 3,000 fungi in just 16 years (SILVA & MINTER 1995, BEZERRA et al. 2017). The complete collection of Batista's full papers that include many species from the Cerrado, is freely retrievable from http://batista.fungibrasil.net/articles. With the transfer of Heringer to Brasília in 1960, the cooperation was intensified including new collections of plant-associated microfungi (ascomycetes and rust fungi), until the passing of 51 years old Batista in 1967 (CARNEIRO 1968). Still, the result was major scientific contribution that remains as an indispensable foundation for the development of mycology in the Cerrado (BATISTA et al. 1962, 1966abc, 1967; BATISTA & PERES 1964, 1965, 1966), with a record of 240 taxa recognized on Cerrado plants, as listed in Dianese et al. (1997). A large set of new ascomycetes were described by Batista and collaborators on material collected by Heringer, from the Cerrado in Paraopeba (State of Minas Gerais), and Distrito Federal, as follows: *Ainsworthia psidii*, *Akaropeltis macheriifolii*, *Akaropeltopsis machaeriifolii*, *Asteromella compositarum*, *A. heringeri*, *A. ourateae*, *Bactrodesmiella aspidospermatis* [= *Pseudocercospora aspidospermatis* (DIANESE & CÂ-

MARA 1994)], *B. tecomae*, *Barnettia byrsonimae*, *B. lucumae*, *Calothyriolum brasiliae*, *C. brasiliense*, *Camarosporium anacardii*, *Camptomeris cassiae*, *Cercospora roupalae*, *C. annonifolii*, *C. cnidoscolifolii*, *C. mataybae*, *C. vochysiae*, *Chaetodiplodina cubensis*, *Chaetophoma clitoriae*, *Ciferriusia piperis*, *Coniothyrium hypericin var. macrospora*, *C. mikaniae*, *Coremium rhopalinum*, *Dicoccum anacardii*, *Didymella smilacina*, *Eudimeriolum aspidospermatis*, *Hendersonia annonicola*, *H. salaciae*, *Leptosphaeria mikaniae*, *Macrophoma brasiliensis*, *Microdiplodia andirae*, *Mycosphaerella byrsonimae*, *M. conspicua*. *M. discophora var. macrospora*, *M. machaerii*, *M. melastomatacearum*, *M. smilacifolii*, *M. tocoyenae, Mysia combreti, Periconia echinochloae, Pestalotiopsis acrocomiorum, P. annonae*, *Phaeoseptoria tecomae*, *P. roupalae*, *Phomachora anacardiicola*, *P. erythroxyli*, *Phyllachora pouteriae*, *P. qualeae, P. rhopalina* var. *macrospora, Phyllachora truncatispora var. macrocarpa, Phyllachora whetzelii var. macrospora, Phyllosticta acrocomiicola*, *P. lucumae*, *P. sizygii*, *Piricauda byrsonimae*, *Placosphaeria mauritiae*, *P. neeae*, *Plectopycnis bignoniacearum*, *Plenotrichella perseae*, *Pycnomyces diptericis*, *Rosenscheldiella rapaneae*, *Septoria sapindacearum*, *Sphaerodothis diplothemiifolii*, *Sphaeropsis myrtaceicola*, *Staibia connari*, *Stomiopeltis tetrasperma*, *Tegaster protiicola, Tegoa tabebuiae, Tuberculina phyllachoricola*, *Vonarxella diptericis* (http://batista.fungibrasil.net/articles, SILVA & MINTER 1995).

Contemplating a remarkable biodiversity hotspot with over 12,000 plant species extending for over 2.2 million sq. km. (MENDONÇA et al. 2008), inspired by the enthusiasm of dedicated students, the Mycological Collection of Herbarium UB (MCHUB) was conceived in 1993 (DIANESE et al. 1997), whose contribution to Cerrado mycology is herein outlined.

CONTRIBUTION OF THE MYCOLOGICAL COLLECTION OF HERBARIUM UB – MCHUB TO THE STUDY OF CERRADO MICROFUNGI

The MCHUB is part of the history of the Instituto de Ciências Biológicas of the Universidade de Brasília (UnB) founded in 1962 (DIANESE 2014, DIANESE & CAFÉ-FILHO 2014, DINIZ & DIANESE 2014). Starting with a US$ 260,000.00 grant to the UnB by the Banco do Brasil Foundation, in 1993, the Mycological Collection of Herbarium UB (MCHUB) remains dedicated exclusively to the study of microfungi associated with native plants from the Cerrado, the second most important Brazilian biodiversity hotspot (MITTERMEIER et al. 1998; MYERS et al. 2000; MYERS 2003). Twelve years later, in 2005, the MCHUB staff was responsible for the V Latin American Mycological Congress. In 2010, as part of the commemoration of Brasília´s 50th Year Anniversary, the MCHUB organized the VI Brazilian Congress of Mycology, with participation of many international mycologists (DIANESE & SANTOS 2010). From 1993, for the last 27 years, the nationwide assessment of the Cerrado mycodiversity by the MCHUB covered epiphytes, parasites, and hyperparasites on leaves of native plants from the Cerrado. These unique collections included mainly Ascomycetes (asexual and sexual morphs), Pucciniales, and a few Ustilaginales in Brazilian national parks located in the Cerrado biome, in other private or official protected areas, and in private sites, such as legally enforced reserves in farms. Dianese et al. (1997), in a review on the Cerrado microfungi already listed a total of 834 species then known to occur in the Cerrado biome that included major contributions by Augusto Chaves Batista (SILVA & MINTER 1995), and Viégas (1943,1944, 1945ac, 1946a).

The MCHUB field surveys for the first time covered the entire Cerrado biome in Central, Southeastern and Northeastern Brazil in a countrywide scale (Figure 1), except for three reserves located in the State of São Paulo, and the Cerrado fragment in the State of Roraima at the extreme North of the country. Hennen and collaborators (CARVALHO-JUNIOR et al. 2008) surveyed in detail the rust fungi in the state of São Paulo, and their data on Cerrado is here incorporated. The MCHUB inventory presently counts 24,572 herborized specimens that also includes *ca* 1,000 myxomycetes. The collection is well preserved, but needs additional taxonomic work, presently with about 20% of the specimens identified to species level.

The MCHUB activity generated in the last 26 years 11 D.Sc. thesis, 17 M.Sc. dissertations, and 65 papers published in prestigious journals dedicated to mycology and plant pathology (Mycologia, Mycological Research, Mycological Progress, IMA Fungus, Phytotaxa, Sydowia, Plant Disease, Plant Pathology), with cover illustrations in Mycologia (GUTERRES et al. 2018) and Plant Disease (AGRA et al. 2018).

Starting in 1993 the material incorporated into the MCHUB was steadily being worked through,

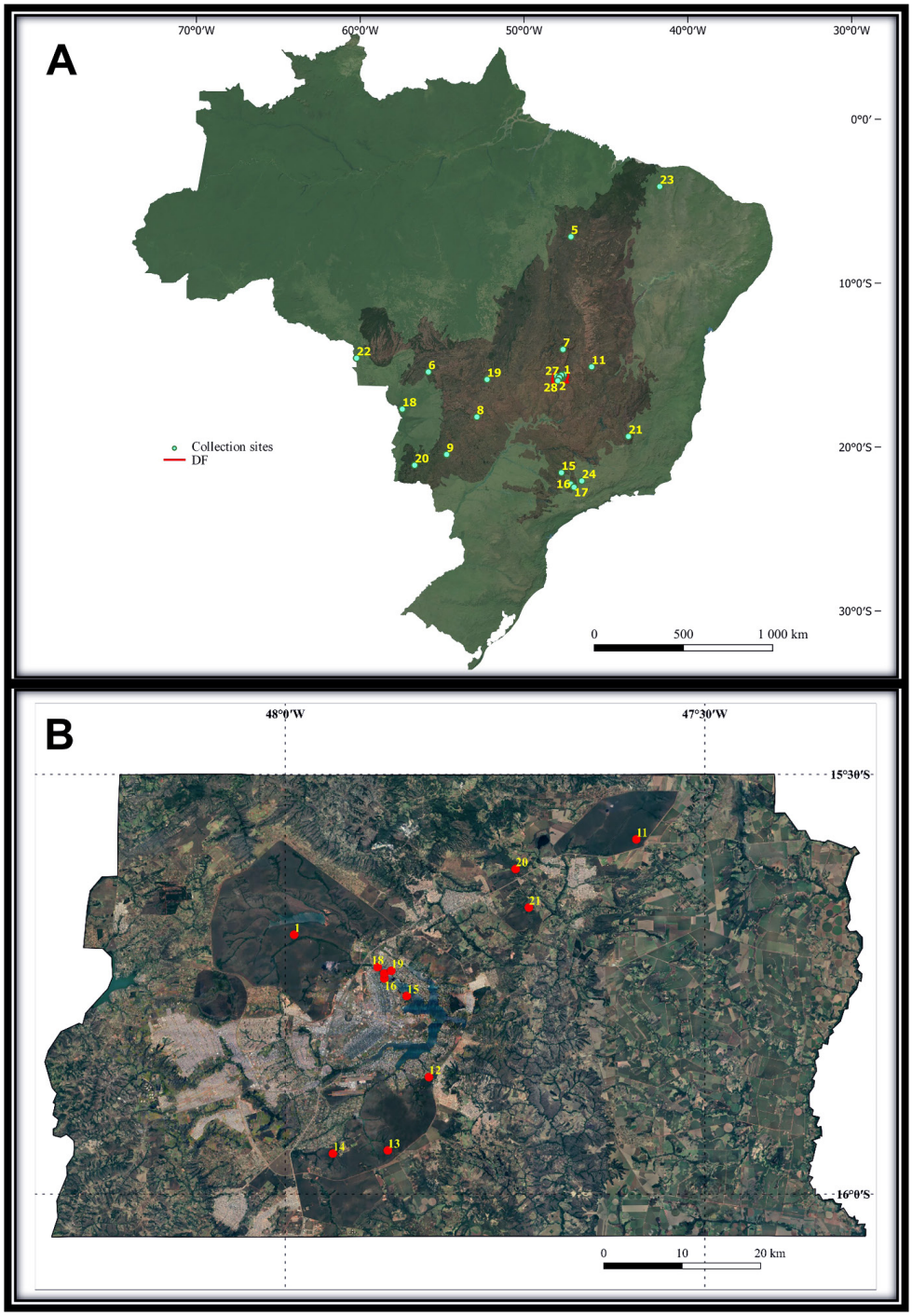


Figure 1. Twenty-eight collection sites within the Brazilian Cerrado in Brazil (A) and Federal District (B) where fungal specimens were recovered from 1993 to 2021, to construct the 24,572-voucher inventory of the MCHUB, plus the rust fungi collected in three Cerrado reserves at the State of São Paulo (CARVALHO-JUNIOR et al. 2008). Collection sites numbered from 1 to 28 in alphabetical order, with indication of the state where the collection site is located are: 1. Águas Emendadas Ecological Station-DF, 2. Brasília Botanical Garden-DF, 3. Brasília Federal Institute Cerrado Reserve, Planaltina-DF, 4. Brasília National Park-DF, 5. Chapada das Mesas National Park-MA, 6. Chapada dos Guimarães National Park-MT, 7. Chapada dos Veadeiros National Park--GO, 8. Emas National Park-GO, 9. Embrapa Beef and Catle Cerrado Reserve at Campo Grande-MS, 10. Embrapa Cerrados Natural Reserve-DF, 11. Grande Sertão Veredas National Park, Arinos-MG, 12. IBGE Ecological Reserve-DF, 13. Lago Norte Residencial Area, Brasília-DF, 14. Lago Norte Park II, Brasília-DF, 15. Luis Antônio Experimental Station-SP, 16. Mogi-Guaçu Experimental Station-SP, 17. Mogi-Mirim Experimental Station-SP, 18. Pantanal Matogrossence National Park, 19. Serra Azul State Park, Barra do Garça-MT, 20. Serra da Bodoquena National Park-MT, 21. Serra do Cipó National Park-MG, 22. Serra Ricardo Franco State Park-MT, 23. Sete Cidades National Park-PI, 24. UFU* Panga Ecological Station, 25. UnB** Arboretum, 26. UnB Biological Experiment Station, 27. UnB Campus Darcy Ribeiro, 28. UnB. *Universidade Federal de Uberlândia **Universidade de Brasília

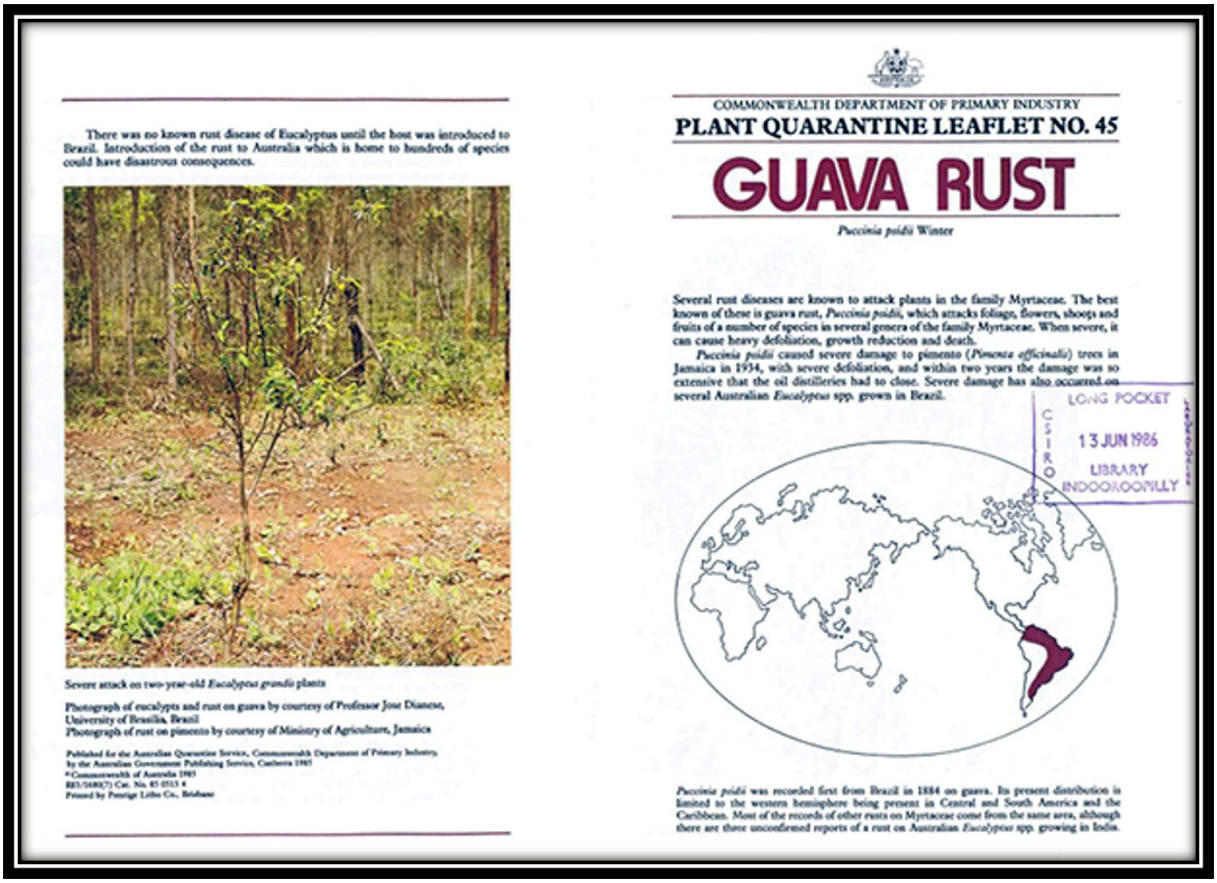
and when over 13,000 specimens were identified as shown in Table 1, five orders predominate, and their geographical distribution will be illustrated in a sequence of maps covering Pucciniales, Capnodiales/Mycosphaerialles, Asterinales, Meliolales and Phyllachorales (Figures 3 to 7). These are all fungi with parasitic ability and in general with high host specificity, showing easily identifiable signs and symptoms in the field. However, as they predominate in an orderly way in such a large sample it is expected that the data would reflect their relative importance in the Cerrado when it comes to leaf associated fungi.

Historically, the plant-associated mycological research at the Universidade de Brasilia predates the MCHUB with a significant event. This highlight involves the first international publication focusing *Austropuccinia psidii* (=*Puccinia psidii*) on *Eucalyptus* species (DIANESE et al. 1983, 1984), a fungus that is found in the Cerrado infecting native Myrtaceae as *Campomanesia adamantium*, *Eugenia dysenterica*, *E. florida*, *Marlierea* sp., *Myrcia linearifolia*, *Plinia cauliflora, and Psidium guajava* (SOUZA 2016). In *C. adamantium,* plants were simultaneously infected by *A. psidii* and by *Phakpsora rossmaniae*, (DIANESE et al. 1993d). The disease caused by *A. psidii* on *Eucalyptus*, previously known in Brazil (FERREIRA 1989), was for the first time reported abroad at the International Congress of Plant pathology in Melbourne in 1983 (DIANESE et al. 1983) and published in the following year (DIANESE et al. 1984). These publications resulted in a historical alert bulletin from the Australian Quarantine illustrating the disease symptoms on *Eucalyptus* and other Myrtaceae from the Americas (NAVARATNAM 1985) (Figure 2). However, 23 years later the biological invasion by that rust fungus was confirmed in Hawaii (UCHIDA et al. 2006), four years before Australia (CARNEGIE et al. 2010). *Austropuccinia psidii* became a major economic problem upon reaching Australian plantations of *Eucaliptus* five years later (CARNEGIE 2015), and an ecological disaster with 45 myrtaceous species in decline starting in 2018 (PEGG et al. 2018). The fungus is already damaging over 375 species of native Myrtaceae in Australia and showing extreme virulence towards *Rhodamnia rubescens* and *Rhodomyrtus psidioides* (FERNÁNDEZ-WINZER et al. 2019). Similar problems are being revealed in New Zealand (SUTHERLAND et al. 2020, TOOME-HELLER et al. 2020), after the detection of the fungus in 2017 (GUY & BARRY 2017), as predicted by Teulon et al. (2015).

The intercontinental spread of *A. psidii*, given

Table 1. Distribution among orders of the exsiccates deposited in the MCHUB that have already been studied.

Order/Family	Number of specimens studied	% Specimens studied
Pucciniales	2,603	19.7
Phylachoralles	2,501	18.9
Capnodiales-Mycosphaerellaceae	1,864	14.1
Meliolales	836	6.3
Asterinales	569	4.0
Pleosporales	487	3.6
Erysiphales	475	3.6
Microthyriales	325	2.5
Diaporthales	324	2.4
Parmulariales	207	1.6
Hypocreales	137	1.0
Botryosphaeriales	91	0.7
Members of 45 other orders with a maximum of 50 specimens studied	2,010	15.6
Total	13,231	100



There was no known rust disease of Eucalyptus until the host was introduced to Brazil. Introduction of the rust to Australia which is home to hundreds of species could have disastrous consequences.

Severe attack on two-year-old *Eucalyptus grandis* plants

Photograph of eucalypts and rust on guava by courtesy of Professor Jose Dianese, University of Brasilia, Brazil
Photograph of rust on pimento by courtesy of Ministry of Agriculture, Jamaica

Published for the Australian Quarantine Service, Commonwealth Department of Primary Industry, by the Australian Government Publishing Service, Canberra 1985
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ISBN 0 642 07 0513 4
Printed by Prestige Litho Co., Brisbane

COMMONWEALTH DEPARTMENT OF PRIMARY INDUSTRY

PLANT QUARANTINE LEAFLET NO. 45

GUAVA RUST

Puccinia psidii Winter

Several rust diseases are known to attack plants in the family Myrtaceae. The best known of these is guava rust, *Puccinia psidii*, which attacks foliage, flowers, shoots and fruits of a number of species in several genera of the family Myrtaceae. When severe, it can cause heavy defoliation, growth reduction and death.

Puccinia psidii caused severe damage to pimento (*Pimenta officinalis*) trees in Jamaica in 1938, with severe defoliation, and within two years the damage was so extensive that the oil distilleries had to close. Severe damage has also occurred on several Australian *Eucalyptus* spp. grown in Brazil.

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Puccinia psidii was recorded first from Brazil in 1884 on guava. Its present distribution is limited to the western hemisphere being present in Central and South America and the Caribbean. Most of the records of other rusts on Myrtaceae come from the same area, although there are three unconfirmed reports of a rust on Australian *Eucalyptus* spp. growing in India.

Figure 2. Historical leaflet issued by the Australian Quarantine in 1985, as a first step of a campaign to prevent introduction of *Austropuccinia psidii*, based on report by Dianese et al. (1983, 1984b).

its broad host spectrum, is the most dramatic example of a massive biological invasion of continents by a rust fungus; from South America spreading through Central and North America, Hawaii, Southeast Asia, Australia, and New Zealand. The first work on the epidemiology of *A. psidii* (TESSMANN et al. 2001) published internationally was released 8 years after the inauguration of the MCHUB.

STUDIES ON CERRADO RUST FUNGI

In the second edition of the classic manual, Illustrated Genera of Rust Fungi, by Cummins & Hiratsuka (1983), the only genus by a Brazilian mycologist was *Porotenus* described 23 years before (VIÉGAS 1960). The contributions of the MCHUB expanded this participation in the new 2003-edition of the Illustrated Genera of Rust Fungi. Cummins & Hiratsuka (2003) accepted 105 genera of Pucciniales, with the significant addition of two new genera from the Cerrado, *Batistopsora*, type species *B. crucis-filii* (DIANESE et al. 1993d), and *Kimuromyces*, type species *K. cerradensis* (DIANESE et al. 1994d), plus the reinstatement of the genus *Mimema* based on *Mimema venturae* (DIANESE et al. 1995). Taxonomic novelties of Cerrado rust fungi with holotypes deposited in the MCHUB were included in Table 2.

The entire inventory of the Cerrado rust fungi already identified and deposited in the MCHUB was shown in the Table 3.

Presently, 112 species of rust fungi are known to possess holotypes collected in the Cerrado as registered in the MCHUB and listed by Hennen et al. (2005) and Souza (2016). These fungi belong to 27 different genera being 18 *Puccinia* spp., 17 *Ravenelia* spp., 15 *Uromyces* spp., 12 *Aecidium* spp., 9 *Prospodium* spp., 7 *Uredo* spp., 6 *Phakopsora* spp., 4 *Cerotelium* spp., 4 *Crossopsora* spp., 2 *Chaconia* spp., 2 *Porotenus* spp. The remaining 16 genera (*Aplopsora, Batistopsora, Catenulopsora, Cerradoa, Cionothrix, Crossopsorella, Dicheirinia, Didymopsora, Dietelia, Diorchidiella, Diorchidium, Kimuromyces, Leptinia, Mavavalia, Mimema, Neopuccinia,* and *Skierka*) have one species originally collected in the Cerrado.

The rust fungi known for the entire Cerrado biome were described from six Brazilian states: Bahia (*Ravenelia corbuloides*, *R. tortuosa*); Goiás (*Aecidium annonae*, *A. byrsonimaae*, *A. invallatum*, *A. meiapontense*, *A. vinnulum*, *A. xylopiae*, *Ciono-*

Table 2. Pucciniales from the Cerrado biome described from 1993 with holotypes deposited in the Mycological Collection of Herbarium UB- MCHUB.

SPECIES / YEAR	SOURCE
Aplopsora hennenii / 1995	1
Batistopsora crucis-filli / 1993*	2
Cerotelium giacometii / 1993	2
Crossopsora hymenaeae / 1994	3
Crossopsorella byrsonimae / 2018*	10
Kimuromyces cerradensis / 1995*	5
Mimema venturae / 1994	6
Phakopsora bluteri / 1993	3
Phakopsora chavesi / 1993	3
Phakopsora rossmanii / 1993	3
Ravenellia bezerrae / 993	2
Ravenellia cerradensis / 2001	7
Ravenellia chapadensis / 2001	7
Ravenellia emaensis / 2001	7
Ravenellia mineirosensis / 2001	7
Ravenellia santos-costae / 1993	2
Ravenellia victoria -rossetii / 1993	2
Skierka divinopolenis / 1993	2
Uromyces galactiae / 2003	8
Uromyces hawksworthii / 2015	9

*Type-species of new genera. [1]Dianese & Santos (1995). [3]Dianese et al. (1993d). [4]Dianese et al. (1993a). [5]Dianese et al. (1994a). [7]Dianese et al. (1995). [8]Dianese et al. (1994d). [21]Rezende & Dianese (2001). [22]Rezende & Dianese (2003). [45]Souza et al. (2015). [48]Souza et al. (2018).

thrix usneoides, *Crossopsora hymenaeae*, *Kimuromyces cerradensis*, *Maravalia perae*, *Phakopsora coca*, *Phakopsora rossmaniae*, *Porotenus bibasiporulus*, *Prospodium destruens*, *Pr. fimbriatum*, *Puccinia banisteriae*, *P. calida*, *P. faceta*, *P. paranahybae*, *P. subcoronata*, *P. uleana*, *Ravenelia dieteliana*, *R. emaensis*, *R. goyazensis*, *R. mineirosensis*, *R. spiralis*, *R. uleana*, *Uredo dalbergiae*, *U. longipedis*, *U. pithecolobii*, *U. psychotriicola*, *Uromyces cnidoscoli*, *Um. dichorisandrae*, *Um. goyazensis*, *Um hawksworhii* (= *A. goyazense*), *Um. manihoticola*, *Um. manihotis*); Distrito Federal (*Cerotelium xylopiae*, *Cerradoa palmaea*, *Crossopsora asclepidiaceae*, *Mimema venturae*, *Phakopsora butleri*, *Ph. chavesii*, *Ph. tocoyenae*. *Ravenelia santos-costae*, *Uromyces galactiae*); Mato Grosso (*Aecidium calosporum*, *A. mattogrossense*, *A. momordicae, Crossopsora angusta*, *Leptinia brasiliensis*, *Puccinia callosa*, *Ravenelia cerradensis*, *Uromyces anthemophilus*, *Um. foveolatus*); Mato Grosso do Sul (*Cerotelium coccolobae*, *Dicheirinia antunesii*, *Prospodium scitulum*, *Ravenelia pernigra*); Minas Gerais (*Aecidium alternantherae*, *A. diospyri-hispidae*, *A. guatteriae*, *A. minimum*, *Aplopsora hennenii*, *Batistopsora crucis-filii*, *Catenulopsora henneneae*, *Cerotelium giacomettii*, *Chaconia maprouneae*, *Didymopsora triumfettae*, *Dietelia duguetiae*, *Diorchidiella verlandii, Phakopsora colubrinae*, *Porotenus concavus*, *Prospodium arrabidaeae*, *Pr. bicolor*, *Pr. cremastum*, *Pr. funalis*, *Pr. pseudozonatum*, *Puccinia cavatica*, *P. circinans*, *P. lisianthi*, *P.*

Table 3. Number of records per taxon, and sites where the rust fungi on native plants from the Cerrado were collected and deposited in the Mycological Collection of Herbarium UB - MCHUB.

TAXON	RECORDS	COLLECTION SITES**
Aecidium jacarandae	2	others*
Aecidium sp.	12	1,16, others
Aecidium ulei	78	9, 11,12,13,17, others
Aplopsora hennenii	19	9,11,13, others
Austropuccinia psidii	82	11,12,13,17, others
Batistopsora crucis-filii	54	3,9,11,17, others
Caeoma sp.	1	others
Catenulopsora henneneae	44	3,13,17, others
Cerotelium fici	1	Others
Cerotelium giacometti	19	9,17, others
Cerotelium malvicolum	1	others
Cerotelium sabiceae	15	5,9,17, others
Cerotelium sp.	1	others
Cerradoa palmaea	59	3,5,9,11,17,19, others

Table 3. Continued

TAXON	RECORDS	COLLECTION SITES**
Chaconia apicrassa	1	7
Chaconia brasiliensis	103	2,9,11,13,14,16,17, others
Chaconia ingae	12	16, others
Chaconia maprouneae	64	9,11,12,13,17,18,19, others
Chaconia sp.	1	others
Cionothrix praelonga	17	others
Coeoma sp.	1	13
Coleosporium elephantopodis	4	others
Coleosporium ipomoeae	5	9, others
Coleosporium plumeriae	6	others
Coleosporium vernoniae	17	16,17,18, others
Crossopsorella byrsonimae	40	6,11,17,18, others
Crossopsora hymenaeae	60	2,9,11,12,13,17, others
Crossopsora sp.	92	8,13,15,17, others
Crossopsorella sp.	2	others
Dasyspora gregária	81	4,6,9,11,16,17, others
Dasyspora sp.	1	others
Desmella aneimiae	2	others
Dietelia duguetiae	30	9,13,15,17, others
Diorchidium copaiferae	20	12, others
Diorchidium sp.	1	16
Esalque holwayi	2	others
Hemileia vastatrix	4	others
Kernkampella appendiculata	5	others
Kimuromyces cerradensis	27	others
Kweilingia divina	2	others
Maravalaia erythroxyli	4	13, others
Maravalia bauhinicola	5	others
Maravalia erythroxyli	44	11,12,15,17, others
Melampsora medusae	3	others
Melampsora salix	1	others
Mimema venturae	24	12,15, others
Olivea tectonae	4	others
Olivea viticis	3	others
Phakopsora arthuriana	1	others
Phakopsora butleri	36	3,9,10,12,13,17, others
Phakopsora cf. pávida	5	9,13,17, others
Phakopsora chavesii	42	4,13, others
Phakopsora colubrinae	1	others
Phakopsora crotalariae	1	others
Phakopsora erythroxyli	1	others
Phakopsora euvites	1	others
Phakopsora gossypii	4	others
Phakopsora mori	2	others

Table 3. Continued

TAXON	RECORDS	COLLECTION SITES**
Phakopsora pachyrhizi	6	others
Phakopsora rossmaniae	20	13, others
Phakopsora sp.	9	3, others
Physopella tocoyenae	1	3
Porotenus concavus	20	11,17, others
Porotenus sp.	1	others
Prospodium appendiculatum	1	others
Prospodium bicolor	1	17
Prospodium impolitum	1	others
Prospodium pseudozonatum	1	others
Prospodium sp.	13	17, others
Prospodium tecomicola	1	others
Puccinia acanthospermi	1	others
Puccinia andropogonis	7	12,16 others
Puccinia arechavaletae	28	12,14,17, others
Puccinia aristae	1	others
Puccinia aspiliae	4	others
Puccinia baccharidis	10	13, others
Puccinia banistariae	77	9,11,12,15,17, others
Puccinia barbatula	64	9,10,11,13,17, others
Puccinia caxiuanensis	1	others
Puccinia cf versicolor	1	others
Puccinia cf. calosa	1	13
Puccinia cf. mandevillae	1	1
Puccinia cf. neorotundata	2	others
Puccinia cnici-oleracei	2	others
Puccinia conyzae	1	others
Puccinia cordiae	2	12, others
Puccinia coronata	2	others
Puccinia crepidis	1	others
Puccinia elongata	3	others
Puccinia farameae	5	4,12,14,15, others
Puccinia gibertii	6	15, others
Puccinia graminis	2	16, others
Puccinia heterospora	7	11, others
Puccinia inrecta	2	1,17
Puccinia lantanae	2	17, others
Puccinia lateritia	2	others
Puccinia leonotidis	1	others
Puccinia levis	7	others
Puccinia melanocephala	1	others
Puccinia mikaniae	2	others
Puccinia mogiphanis	1	others
Puccinia neorotundata	2	7

Table 3. Continued

TAXON	RECORDS	COLLECTION SITES**
Puccinia niederleini	4	others
Puccinia oxalidis	4	13, others
Puccinia palicourea	33	others
Puccinia pelargonii-zonalis	3	others
Puccinia pipta	60	9,11,12,13,17, others
Puccinia psychotriae	1	9
Puccinia purpurea	4	others
Puccinia recondita	1	others
Puccinia rubigo-vera	1	others
Puccinia rugose	3	12, others
Puccinia sherardiana	1	others
Puccinia smilacis	1	others
Puccinia sorghi	2	13, others
Puccinia sp.	32	13,17, others
Puccinia substriata	1	others
Puccinia thaliae	5	others
Pucciniaceae non identified	2	others
Pucciniales non identified	298	
Pucciniosira pallidula	1	others
Pucinia cnici-oleracei	1	others
Ravenelia bezerrae	20	17, others
Ravenelia cerradensis	32	5,9,17, others
Ravenelia chapadensis	17	3,4,5,17, others
Ravenelia densifera	5	others
Ravenelia dieteliana	4	4,17, others
Ravenelia emaensis	17	3, others
Ravenelia geminipora	53	2,11,16,17, others
Ravenelia goyazensis	2	others
Ravenelia hieronymi	6	others
Ravenelia lonchocarpi	2	others
Ravenelia mimosae-sensitivae	17	3,17, others
Ravenelia mineiroensis	1	3
Ravenelia pernigra	2	others
Ravenelia pileolarioides	1	others
Ravenelia santos-costae	70	9,11,13,15,17, others
Ravenelia sp.	32	3,13,16,17, others
Ravenelia sp. nov.	1	others
Skierka divinopolensis	31	2,9,16, others
Sphaerophragmium acaciae	7	others
Sphenospora smilacina	2	9, others
Tranzschelia discolor	1	others
Tranzschelia pruni-spinosae	5	others
Tranzschelia sp.	1	others
Uredo borreriae	1	others

Table 3. Continued

TAXON	RECORDS	COLLECTION SITES**
Uredo eriosemae	1	11
Uredo jatrophicola	1	others
Uredo lafVðensiae	11	others
Uredo mogy-mirim	1	others
Uredo sp.	39	11,13,17, others
Uredopeltis guettardae	5	1
Uromyces appendiculatus	5	13, others
Uromyces bauhineae	48	4,9,11,15,17, others
Uromyces bauhinicola	1	others
Uromyces bidenticola	1	others
Uromyces bradburyae	1	others
Uromyces cestri	1	others
Uromyces costaricensis	1	others
Uromyces dolicholii	1	others
Uromyces eriosemae	3	9, others
Uromyces euphorbiae	4	13, others
Uromyces floralis	4	others
Uromyces foveolatus	2	others
Uromyces galactiae	4	17, others
Uromyces goyazensis	13	9,12,13, others
Uromyces hawksworthii	52	9,11,13,17, others
Uromyces hemmendorffii	1	others
Uromyces ipatingae	1	others
Uromyces manihotis	4	others
Uromyces mikaniae	3	others
Uromyces myrsines	1	others
Uromyces neurocarpi	12	17, others
Uromyces perlebiae	1	others
Uromyces scleriae	2	others
Uromyces setatiae-italicae	3	others
Uromyces sp.	8	1,6, others
Uromyces tolerandus	1	others
Uromyces transversalis	5	others
Uromyces viegasii	7	others
Uromyces vignae	1	others

others*= Collections in private properties, not from protected sites. ** **Oficial Cerrado Reserves**:1-Chapada dos Guimarães National Park, 2-Serra do Cipó National Park, 3-Emas National Park, 4-Grande Sertão Veredas National Park, 5-Chapada dos Veadeiros National Park, 6-Chapada das Mesas National Park, 7-Serra da Bodoquena National Park, 8-Sete Cidades National Park, 9-Brasília National Park, 10-Pantanal Matogrossense National Park, 11-Brasilia Botanic Garden, 12-Brasília IBGE Reserve, 13-Brasília Fazenda Água Limpa, 14-Panga-Uberlândia Reserve, 15-Embrapa Reserve, Campo Grande, 16-Embrapa Reserve, Brasília, 17-Águas Emendadas Ecological Station, 18-Serra de Ricardo Franco State Park, 19-Serra Azul State Park, 20- Mogi Mirim Experimental Station, 21-Luis Antônio Experimental Station, 22- Mogi Guaçu Experimental Station.

opulentissima, *P. velata*, *Ravenelia geminipora*, *R. lata*, *R. lonchocarpi*, *R. septata*, *Skierka divinopolensis*, *Uredo bauhiniae*, *U. cassiae-rugosae*, *U. hyptidis*, *Uromyces. brasiliensis*, *Um. loranthi*, *Um. myrsines*); Roraima (*Ravenelia armata*); São Paulo (*Cerotelium figueiredeae*, *Chaconia brasiliensis*, *Crossopsora byrsonimae*, *Diorchidium copaiferae*, *Maravalia erythroxyli* (= *Puccinia erythroxyli*), *Neopuccinia bursa*, *Prospodium impolitum*, *Pr. palmatum*, *Puccinia achyroclines*, *P. guassuensis*, *P. manuelensis*, *P. seor-*

sa, P. valentula, *P. vinulla*, *Ravenelia dentifera*, *R. microspora*, *Uredo mogy-mirim*, *Uromyces vicinus*).

Among the valid names mentioned, 32 have the authorship connected with Prof. Joe F. Hennen, retired from the Arthur Fungarium at Purdue University, now connected with the Botanical Research Institute-Texas. He is an outstanding expert in rust fungi from the Cerrado, where he successfully collected for over 22 years. As registered in Fungarium IBI-Instituto Biológico de São Paulo, his first collection in the Cerrado was on September 02, 1976 (Accession number: IBI-12441) when he and Y. Ono described *Cerradoa palmaea* in Brasilia at the Estação Ecológica de Águas Emendadas. His last record at IBI dates June 12, 1999 (Accession number: IBI18914), in a Cerrado protected area at Mogi Guaçu, State of São Paulo (FIGUEIREDO & HENNEN 1998, CARVALHO-JUNIOR et al. 2008). Hennen topped his activities in Brazil with a monumental contribution, the publication of a 490-page review of the Brazilian Pucciniales that became the main repository of information for anybody dealing with Brazilian rust fungi (HENNEN et al. 2005).

At MCHUB, for the first-time rust fungi were described on two important plant families from the Cerrado: Caryocaraceae, *Cerotelium giacomettii*, on *Caryocar brasiliense*; and *Aplopsora hennenii* on *Qualea multiflora*, a member of the Vochysiaceae (DIANESE et al. 1993d, DIANESE & SANTOS 1995). A second species of the rare genus *Skierka* (*S. divinopolensis*) was described on *Matayba guianensis* (Sapindaceae) from the Cerrado (DIANESE et al. 1993d, HENNEN et al. 2005). Another highlight was the complete description of the first *Uromyces* species (*U. hawksworthii*) from the Cerrado infecting a plant hemiparasite, *Phthirusa stelis* (Lotanthaceae) (SOUZA et al. 2015), previously described in its asexual form (*Aecidium goyazense*) by Hennings (1895).

Dianese et al. (1993d), surveying the rust fungi on Fabaceae, described initially two new *Ravenelia* species (*R. bezerrae*, and *R. santos-costae*), and later *R. cerradensis*, *R. chapadensis*, *R. emaensis*, and *R. mineirosensis* (Rezende and Dianese 2001, 2003b). Presently, with six *Ravenelia* species published, the contribution by MCHUB comprises *ca* 15% of the species known in Brazil (HENNEN et al. 2005). A set of three more *Ravenelia* species is being processed, including a new genus in family Raveneliaceae.

Cerradoa is the first genus of rust fungi from the Cerrado and first Pucciniales with sexual and asexual morphs present on a palm tree. However, the host was originally misidentified as *Attalea geraensis* (HENNEN & ONO 1978), but with the reexamination of the holotype, PUR F18664, it became clear that the real host is *Syagrus comosa*, as well as a preliminary phylogenetic study allocated the genus in family Pucciniaceae (GALVÃO-ELIAS et al. 2018). The detailed phylogeny of the genus has been submitted for publication and is in final review by Mycologia. A second host species of *C. palmaea* (*S. flexuosa*) is long known from the Cerrado (DIANESE et al. 1992).

Dianese et al. (1994a) described a new *Crossopsora* species (*C. hymenaeae*) on *Hymenaea stigonocarpa,* the first *Crossopsora* on Fabaceae in the Cerrado. However, the *Crossopsora* species most frequently found in this biome is *C. byrsonimae* infecting *Byrsonima* species (Malpighiaceae). Surprisingly, recent review including molecular phylogeny showed that this species does not belong in *Crossopsora*. It belongs in the new genus *Crossopsorella*, type species *Crossopsorella byrsonimae* (SOUZA et al. 2018), the fourth genus from the Cerrado, after *Porotenus* (VIÉGAS 1960), *Batistopsora* (DIANESE et al. 1993d) and *Kimuromyces* (DIANESE et al. 1995). A fifth genus, *Neopuccinia* (MARTINS-JUNIOR et al. 2019), completes the set of cerradoan rust genera.

Carvalho-Junior et al. (2008) in a detailed assessment (from 1975 until 1999), covering three Cerrado reserves (Mogi Mirim, Mogi Guaçu, and Luís Antonio), controlled by the State of São Paulo, Brazil, collected 1,176 specimens, and identified 157 species of Pucciniales on native Cerrado plants. The majority (120 species) dispersed among the genera *Puccinia* (53), *Uromyces* (19), *Aecidium* (10), *Phakopsora* (10), *Prospodium* (8), *Uredo* (6), *Crossopsora* (5), *Ravenelia* (5) and *Coleosporium* (4). The hosts belonged in 128 genera, distributed in 49 botanical families. The taxonomical novelties for the State of São Paulo were published later (CARVALHO-JUNIOR & HENNEN 2009, 2010, 2012, 2018. 2019, MARTINS-JUNIOR et al. 2019), that included *Puccinia manuelensis*, *P. guassuensis* and *Neopuccinia bursa*. In addition, Carvalho-Junior & Hennen (2008) described four new species of rust fungi from Goiás (*Mavavalia perae, Prospodium destruens, Pr. fimbriatum, Puccinia calida*), two from Minas Gerais (*Prospodium funalis, Puccinia opulentíssima*, and *Dicheirinia antunesii* from Mato Grosso do Sul.

Finally, to demonstrate the entire collection effort developed in the Cerrado by the MCHUB and IBI, the map in Figure 3 expresses the extension and intensity of field sampling directed to rust fungi, covering the critical sites within the entire Cerrado biome.

STUDIES ON ASCOMYCETES

Ascomycetes asexual morphs

Contributions of the MCHUB to the study of Cerrado asexual ascomycetes were summarized in the Table 4. The first species ever described in the MCHUB was *Phloeosporella flavio-moralis* on *Eugenia lutescens* (DIANESE et al. 1993b), followed by *Coniella costae* on *Myrcia tomentosa* (DIANESE et al. 1993a), and *P. kytajimae* on *E. dysenterica* (DIANESE et al. 1993c).

The cercosporoid fungi remains as the main group studied at the MCHUB with a total of 77 introduced taxa, distributed in genera *Asperisporium*, *Cercospora, Mycovellosiella* (=*Passalora* p.p.), *Passalora*, *Phaeoramularia* (=*Passalora*), *Prathigada* (=*Passalora*), *Pseudocercospora, Sirosporium,* and *Zasmidium* (=*Stenella*). Among them *Pseudocercos-*

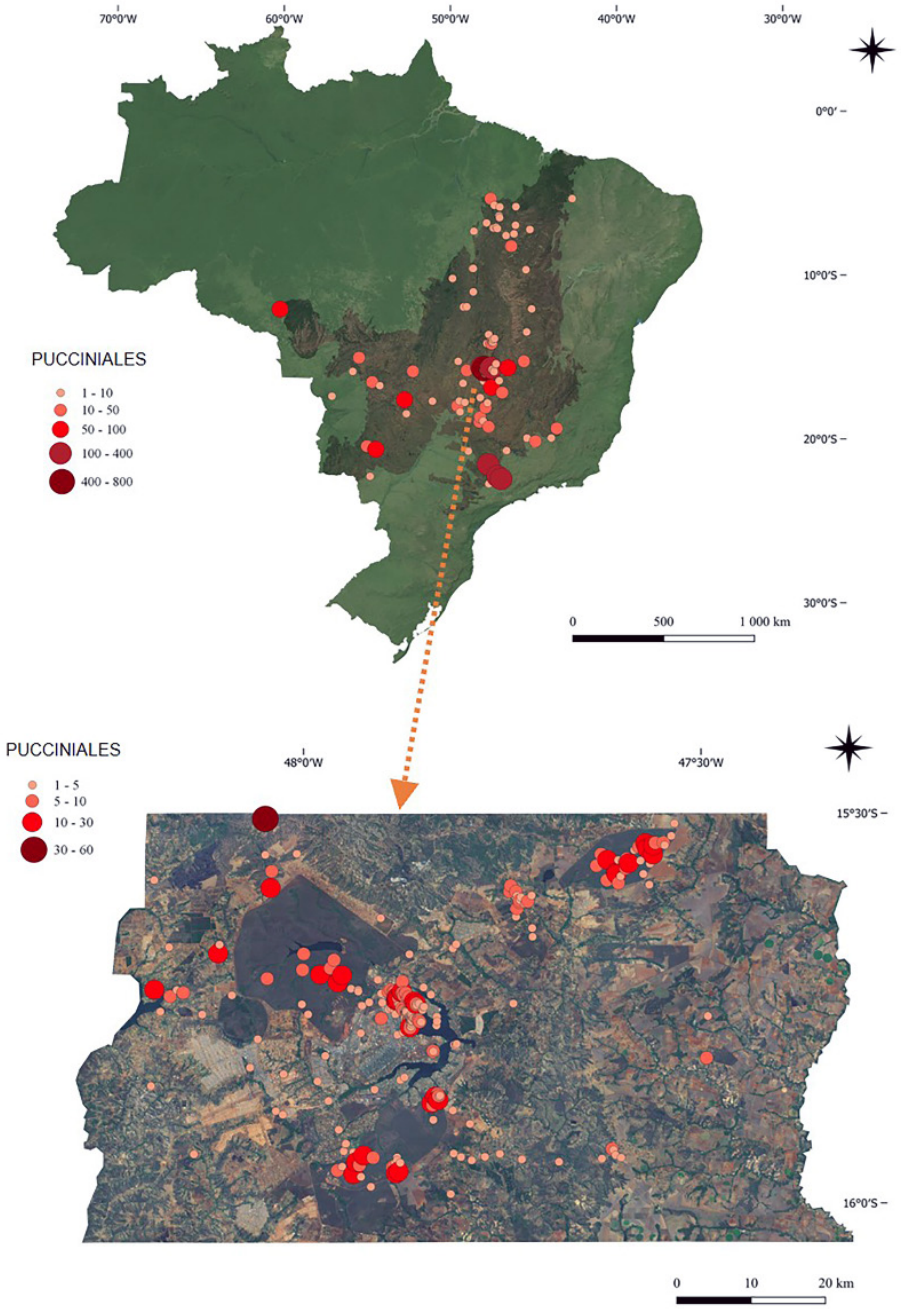

Figure 3. Collection sites in the Brazilian Cerrado (top map), and a detailed view of the activity in the Federal District (bottom), related to the 2,603 specimens of Pucciniales incorporated into the MCHUB starting in 1993. Diameters of the circles are proportional to the number of specimens collected in each site.

pora is the most important genus with 55% of the cercosporoid fungi described, followed by *Passalora*, and *Cercospora* (Table 4) (DIANESE et al. 1999; DIANESE et al. 2008; DIANESE et al. 2014; DORNELO-SILVA & DIANESE 2003; DORNELO-SILVA et al. 2007; FURLANETTO & DIANESE 1999; HERNÁNDEZ-GUTIÉRREZ & DIANESE 2008, 2009, 2014ab; HERNÁNDEZ-GUTIÉRREZ et al. 2014, 2015; INÁCIO & DIANESE 1998).

Another set of species that deserve special recognition are the eight new genera of trichomatous hyphomycetes found on members of the *Icacinaceae, Malphigiaceae, Fabaceae, Dilleniaceae, Chrysobalanaceae*, and *Caryocaraceae*, revealing the trichomes as an unusual site of epiphyllous fungal diversity (PEREIRA-CARVALHO et al. 2009a), sometimes with parasitic ability (CANTRELL et al. 2011). An ongoing contribution reveals that a fungus hyperparasite of a *Phyllachora* species, in leaves of *Eugenia florida* from the Cerrado, treated as a basidiomycete for 134 years since its original description by Spegazzini (1886) as *Microcera clavariella*, and named *Clavaria parasitica* Viégas & Texeira (VIÉGAS & TEIXEIRA 1945), was shown now to be an ascomycete, *Cladosterigma clavariellum*, inserted in Gomphillaceae (Lecanoromycetes, Graphidales), a family of predominantly lichenized fungi (SANTOS et al. 2020).

Contribution of the HCHUB to the taxonomy of the asexual ascomycetes was included in the Table 4.

Table 4. Ascomycete asexual morphs with holotypes in the Mycological Collection of Herbarium UB, starting on 1993, showing 105 new taxa, with 12 type species of new genera.

Species / Year	Source
Alternaria qualeae / 2003	**1**
Asperisporium galactiae / 2015	**2**
Cercospora jatrophiphila / 2014	**3**
Cercospora mimosae-sensitivae / 2009	**4**
Cercospora ochromae / 2008	**5**
Cercospora tabebuia-impetiginosae / 1998	**6**
Coniella costae / 1993	**7**
Dinemasporium duguetiae / 1998	**8**
Echinoconidiophorum cerradense / 2009*	**9**
Fumagospora tabebuiae / 1998	**6**
Globoconidiopsis cerradensis / 2009*	**9**
Globoconidium cerradense / 2009*	**9**
Harknessia qualeae / 1998	**8**
Harknessia salvertiana / 1998	**8**
Helminthosporiomyces cerradensis / 2009*	**9**
Janetia salvertia / 2003	**1**
Mycovellosiella micranthae / 1996	**10**
Oidium bauhiniicola / 2006	**26**
Parastenella callisthenis-fasciculatae / 2007	**12**
Passalora acosmii / 2009	**4**
Passalora chamaecristae-orbiculatae / 2009	**4**
Passalora chamaecristicola / 2009	**4**
Passalora chapadensis / 2014	**13**
Passalora dalbergiae / 2009	**4**
Passalora delamonicae / 2014	**13**
Passalora eitenii / 1994	**14**
Passalora guimaranhensis / 2014	**13**
Passalora machaerii / 2009	**4**
Passalora myracrodruonis / 2003 [≡ *Mycovellosiella myracrodruonis*]	**11**
Passalora peixotoae / [≡ *Mycovellosiella peixotoae*]	**10**
Passalora qualeae / 2003	**1**
Passalora schefflerae / 2008	**5**
Passalora tabebuiae-ochraceae / 2006	**15**
Passalora cerradensis / 2014	**16**
Passalora peixotae-reticulatae / 2014	**16**
Passalora brasilianensis / 2014	**16**
Passalora peixotoae-goianae / 2014	**16**
Passalora austroplenckiae / 2013 [≡ *Prathigada austroplenckiae* / 2008]	**5**
Passalora backmanii / 2013 [≡ *Prathigada backmanii* / 1998]	**21**
Passalora caesalpiniae / 2009	**4**
Passalora chuppii / 2003 [≡ *Phaeoramularia chupii* / 1998]	**10**
Passalora pyrostegiae [≡ *Phaeoramularia pyrostegiae* / 1996]	**10**
Periconiella longispora / 2003	**1**
Periconiella qualeae-grandiflorae / 2003	**1**
Phaeoidiomyces qualeae / 2004*	**17**

Table 4. Continued

Species / Year	Source
Phaeoramularia rubida / 1996	**10**
Phaeostilbelloides velloziae / 2015*	**18**
Phloeosporella flavio-moralis / 1993	**19**
Phloeosporella kitajimae / 1993	**20**
Phragmoconidium cerradense / 2009*	**9**
Phyllosticta xylopiae-sericeae / 1998	**8**
Polychaeton tabebuiae / 1998	**6**
Pseucercospora astroniiphila / 2008	**5**
Pseudocercospora acosmii-subelegantis / 2015	**2**
Pseudocercospora annellidica / 2013	**23**
Pseudocercospora aquae-emendadasensis / 2015	**2**
Pseudocercospora astronii / 2008	**5**
Pseudocercospora austroplenckiae / 2008	**5**
Pseudocercospora banisteriopsis-megaphyllae / 2014	**13**
Pseudocercospora bonducella / 2009	**4**
Pseudocercospora byrsonimae-basilobae / 2013	**23**
Pseudocercospora byrsonimae-coccolobifoliae / 2013	**23**
Pseudocercospora byrsonimicola / 2013	**23**
Pseudocercospora byrsonimigena / 2013	**23**
Pseudocercospora caesalpiniicola / 2009	**4**
Pseudocercospora campograndensis / 2013	**23**
Pseudocercospora chamaecristigena / 2009	**4**
Pseudocercospora eriothecae / 2008	**5**
Pseudocercospora exilis / 2009	**4**
Pseudocercospora grajauensis / 2013	**23**
Pseudocercospora luzianiensis / 2009	**4**
Pseudocercospora matogrossoensis / 2014	**13**
Pseudocercospora mutabiliconidiophorum / 2013	**22**
Pseudocercospora passiflorae-setaceae / 2008	**25**
Pseudocercospora pediformiconidiorum / 2013	**22**
Pseudocercospora planaltinensis / 2013	**22**
Pseudocercospora protii / 2008	**5**
Pseudocercospora pseudobombacis / 2008	**5**
Pseudocercospora sennae / 2015	**2**
Pseudocercospora sennae-rugosae / 2015	**2**
Pseudocercospora stryphnodendri / 2015	**2**

Table 4. Continued

Species / Year	Source
Pseudocercospora subcuticularis / 2015	**2**
Pseudocercospora subhyalina / 2013	**2**
Pseudocercospora tabebuiae-caraibae / 2006	**15**
Pseudocercospora uwebrauniana / 2014	**13**
Pseudocercospora zeyheriae / 1999	**23**
Pseudocercospora aspidospermatis / 1994	**24**
Pseudocercospora bolkanii / 1999	**22**
Pseudocercospora luzardii / 1999	**22**
Pseudocercospora tabebuiae-roseo-albae / 1998	**6**
Pseudocercospora urenae / 1996	**10**
Septoria tabebuiae-impetiginosae / 1998	**6**
Sirosporium sclerolobii / 2015	**2**
Zasmidium cyrtopodii 2014 / [≡ *Stenella cyrtopodii* / 2007]	**12**
Trichomatoclava cerradensis / 2009*	**21**
Trichomatomyces byrsonimae / 2004*	**17**
Trichomatosphaera cerradensis / 2009*	**9**
Trichosporodochium cerradensis / 2004*	**17**
Velloziomyces ramosiconidialis / 2015*	**18**
Vesiculohyphomyces cerradensis / 2009*	**9**
Zamidium ocotei / 2015	**2**
Zasmidium erythroxyli-campestris / 2015	**2**
Zasmidium erythroxylicolum / 2015	**2**
Zasmidium erythroxyli-suberosi / 2015	**2**
Zasmidium sclerolobii / 2015	**2**

*Type-species of new genera. [1]Dornelo-Silva & Dianese (2003). [2]Hernández-Gutiérrez et al. (2015). [3]Dianese et al. (2014). [4]Hernández-Gutiérrez & Dianese (2009). [5]Hernández-Gutiérrez & Dianese (2008). [6]Inácio & Dianese (1998). [7]Dianese et al. (1993a). [8]Furlanetto & Dianese (1997). [9]Pereira-Carvalho et al (2009). [10]Inácio et al. (1996). [11]Inácio & Dianese (1999). [12]Dornelo-Silva et al. (2007). [13]Hernández-Gutiérrez et al. (2014b). [14]Medeiros & Dianese (1994). [15]Inácio & Dianese (2006). [16]Hernández-Gutiérrez et al. (2014a). [17]Dornelo-Silva & Dianese (2004). [18]Armando et al. (2015). [19]Dianese et al. (1993b). [20]Dianese et al. (1993c). [21]Furlanetto & Dianese (1999). [22]Hernández-Gutiérrez et al. (2014b). [23]Dianese et al. (1999). [24]Dianese & Câmara (1994). [25]Dianese et al. (2008). [26]Braun et al. (2006).

As the cercosporoid fungi (Order Capnodiales, Family Mycosphaerellaceae) constitute the main group of asexual ascomycetes described and deposited in the MCHUB, the distribution of this fungal group through the sites in the Cerrado where extensive collection occurred was shown in the Figure 4.

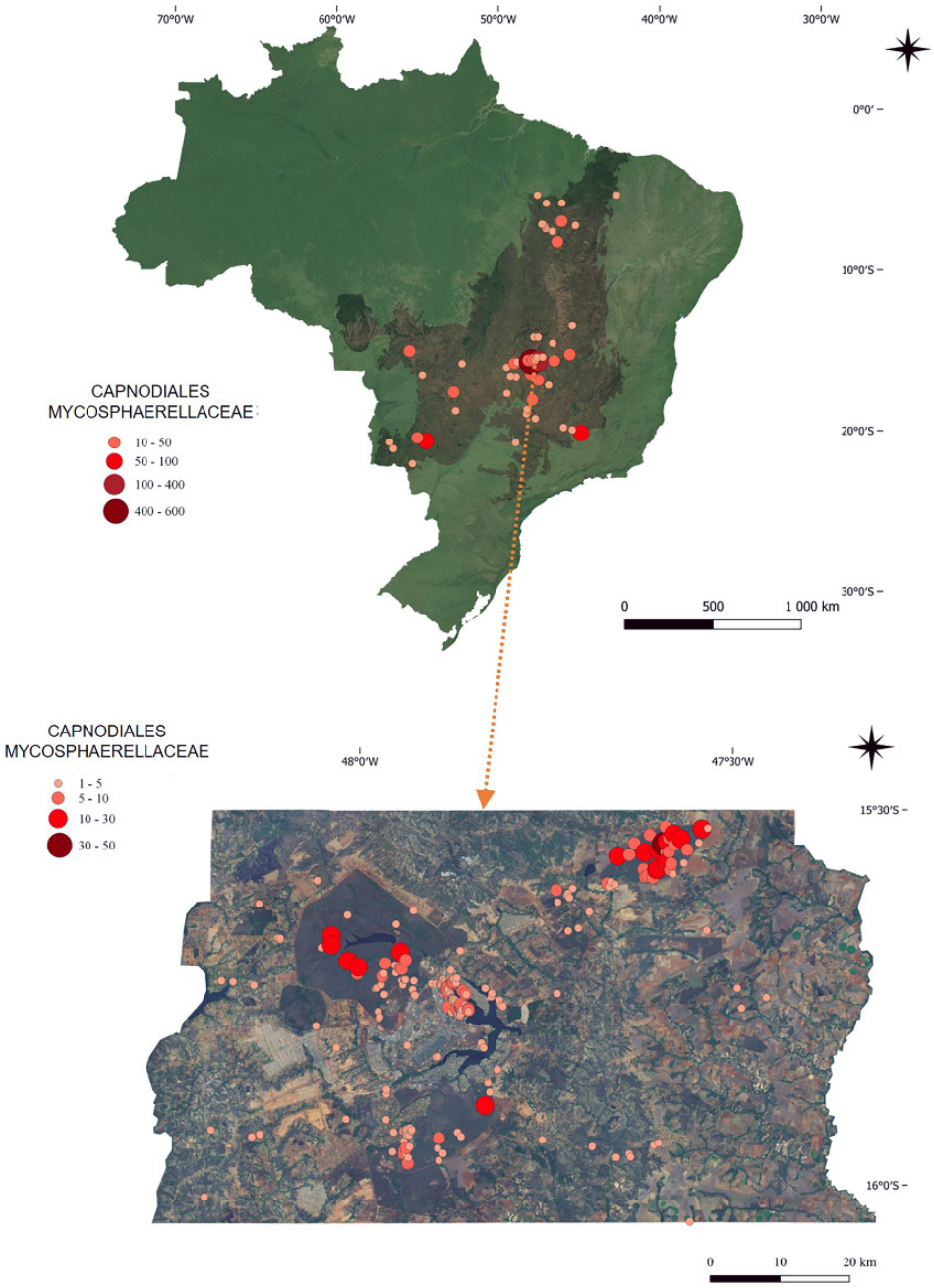

Figure 4. Collection sites in the Brazilian Cerrado (top map), and a detailed view of the activity in the Federal District (bottom), related to the 1,864 specimens of Capnodiales- Mycosphaerellaceae incorporated into the MCHUB starting in 1993. Diameters of the circles are proportional to the number of specimens collected in each site.

STUDIES ON ASCOMYCETE SEXUAL MORPHS

In Table 5, the main novelties were the introduction of three new genera of ascomycetes, *Chaetothyriomyces*, *Plurispermiopsis*, and *Wilmia* (= *Letendraea*), and a set of four new *Phyllachora* species, and two new species in family Parmulariaceae (*Dothidasteroma psidii*, and *Hysterostomella connari*). Collection effort related to the three main orders of ascomycetes (Asterinales, Meliolales and Phyllachorales) found in the Cerrado are shown in Figures 5, 6, and 7.

Batista and collaborators also focused the Cerrado ascomycetes, with most of his contributions included in Silva & Minter (1995). Specifically dedicated to the Cerrado sexual ascomycetes are Batista & Peres (1966a), and Batista et al. (1966abcdf, 1967a).

Viégas (1943, 1944, 1947) and Viégas & Cardoso (1944), studying a set of Cerrado fungi described the sexual morphs of *Brasiliomyces* (type species *Brasiliomyces malvastri*), *Capnodium erythrinicola*, *Catacauma davillae*, *C. nigerrimum* (= *Phyllachora nigerrima*), *C. qualeae* Viégas (=*Phyllachora qualeae*), *C. trucatisporum* (=*Phyllachora truncatis-*

Table 5. Ascomycete sexual morphs described and deposited in the Mycological Collection of Herbarium UB, starting on 1993, containing 27 new taxa described, with three type species of new genera.

Species / Year	Source
Anhelia tabebuiae / 1998	1
Asterina cerradensis / 2019	2
Asterina malvacearum / 2019	2
Lembosia matogrossensis / 2019	2
Lembosia miconiphylla / 2019	2
Asterolibertia bahiensis / 2016	3
Asterolibertia barrinhensis / 2016	3
Asterolibertia campograndensis / 2016	3
Asterolibertia parinaricola / 2016	3
Camarotella brasilienses / 2008	4
Chaetothyriomyces brasiliensis / 2009*	5
Cirsosia splendida var. laevigata / 2016	3
Dictyonella tabebuiae / 1998	1
Dothidasteroma psidii / 2011	5
Hysterostomella connari / 2012	6
Meliola albiziae-polyanthae / 2014	7
Meliola bodoquensis / 2014	7
Meliola sweetiae / 2014	7
Meliola andirae-humilis / 2014	7
Meliola eriosemae / 2014	7
Phyllachora cerradensis / 2016	8
Phyllachora ermidensis / 2016	8
Phyllachora furnasensis / 2016	8
Phyllachora myrciariae / 2016	8
Phyllachora nigerrima / 2016	8
Plurispermiopsis cerradensis / 2010*	9
Uncinula viegasii / 1995	10
Uncinulla alvinii / 1995	10
Uncinulla heringeriana / 1995	10
Wilmia (= *Letendraea* Sacc.) *brasiliensis* / 2001*	11

*Type-species of new genera published. [1]Inácio & Dianese (1998). [2]Firmino et al. (2019). [3]Firmino et al. (2016). [4]Souza et al. (2008). [4]Pereira-Carvalho et al. (2009). [5]Inácio et al. (2011). [6]Inácio et al. (2012). [7]Soares & Dianese (2014). [8]Santos et al. (2016). [9]Pereira-Carvalho et al. (2010). [10]Dianese & Dianese (1995). [11]Dianese et al. (2001).

pora), *Diplochorella indaia*, *Episphaerella didymopanacis*, *E. myrciae*, *Elsinoe tecomae*, *Gaillardiella caryocana, Lasmenia flavozonata, Nectria erythroxylifoliae* (=*Trichonectria erythroxylifoliae*), *Perisporina roupalae*, *Phyllachora myrciae-rostratae*, *Queirozia,* type species *Queirozia turbinata* (=*Pleochaeta turbinata*), and *Trabutia pampulhae*.

The solid repository represented by the MCHUB and the addition of the phylogenetic species concept allows for a wider and more effective taxonomical work and insertion of taxa in the phylogenetic system internationally adopted. Thus, the genera *Apiosphaeria* (type species *A. guaranitica*) and *Phaeochorella* (type species *P. parinari*) were long accommodated in the order Phyllachorales. Recent studies focusing on morphology and molecular phylogeny revealed that both genera belong in Diaporthales (GUTERRES et al. 2018, 2019). In addition, *Pheochorella* was found to belong in a new family Phaeochorellaceae (GUTERRES et al. 2019). In conclusion, the knowledge generated in the MCHUB, with the new molecular tools, offers the opportunity for advancement of taxonomical work with Cerrado fungi.

International recognition for the work at MCHUB was recently expressed by cover pictures shown in fascicles of Plant Disease (AGRA et al. 2018) showing the symptoms of a false smut on beans, and a cover of a Mycologia fascicle illustrated by pictures of *Phaeochorella*, the type genus of the new family Phaeochorellaceae (GUTERRES et al. 2019). These were the first such happenings ever for Brazilian mycologists in both journal that belong to the American Phytopathological Society and Mycological Society of America, respectively (Figure 8).

GEOGRAPHICAL REPRESENTATION OF THE CERRADO MYCODIVERSITY IN THE MCHUB

The collection inventory contains microfungi collected from the Cerrado in Federal District and in the States of Bahia, Goiás, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Tocantins, Rondônia, Maranhão, and Piauí. Through the years the field work within the Federal District was shown to be more intensive than in any of the states because of the availability of local resources and the extension and diversity of the natural reserves within its limits. Presently, there are 14,446 fungal specimens deposited in the MCHUB, collected in the Federal District,

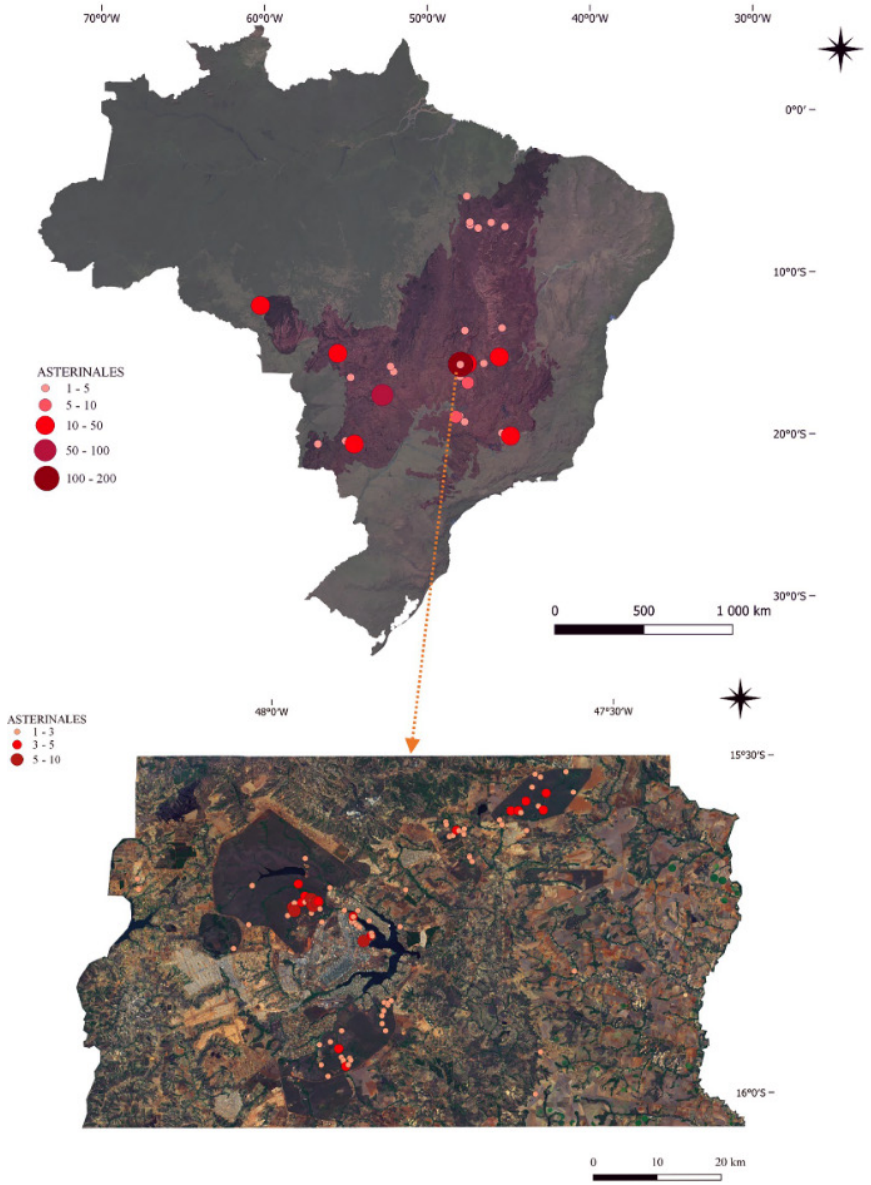

Figure 5. Collection sites in the Brazilian Cerrado (top map), and a detailed view of the activity in the Federal District (bottom), related to 569 specimens of Asterinales- Asterinaceae incorporated into the MCHUB starting in 1993. Diameters of the circles are proportional to the number of specimens collected in each site.

where the major sources of material are: Brasilia National Park, Águas Emendadas Ecological Station, Brasilia Botanical Garden, UnB Fazenda Água Limpa, IBGE Cerrado Reserve, Embrapa Planaltina Cerrado Reserve, Brasilia National Forest, Cafuringa Preservation Area, Cerrado within the 300 hectares UnB Campus, UnB Biological Experiment Station and Arboretum. In Goiás the 2,225 specimens came mainly from two National Parks, Chapada dos Veadeiros in Alto Paraiso and Parque das Emas in Mineiros, Nova India Farm and Vereda do Gato Reserve in Cristalina. In Maranhão, 812 specimens were collected in two different expeditions. During the first expedition the samples were collected along the highways starting in Imperatriz and going to Balsas via Grajaú, concentrating mostly around the Embrapa Experiment Station in Balsas. The round trip involved collecting along the road to Loreto, Extremo, Carolina, and back to Imperatriz. The other field trip was concentrated in the Chapada das Mesas National Park, in Carolina.

The 1,381 specimens from Mato Grosso were distributed among Chapada dos Guimarães National Park, Pantanal National Park, Serra Azul State Park in Barra do Garça, Serra Ricardo Franco State Park in Vila Bela da Santissima Trindade, Serra do Petrovina to Rondonópolis along BR 364 Highway. In the state of Mato Grosso do Sul 1,060 specimens were reco-

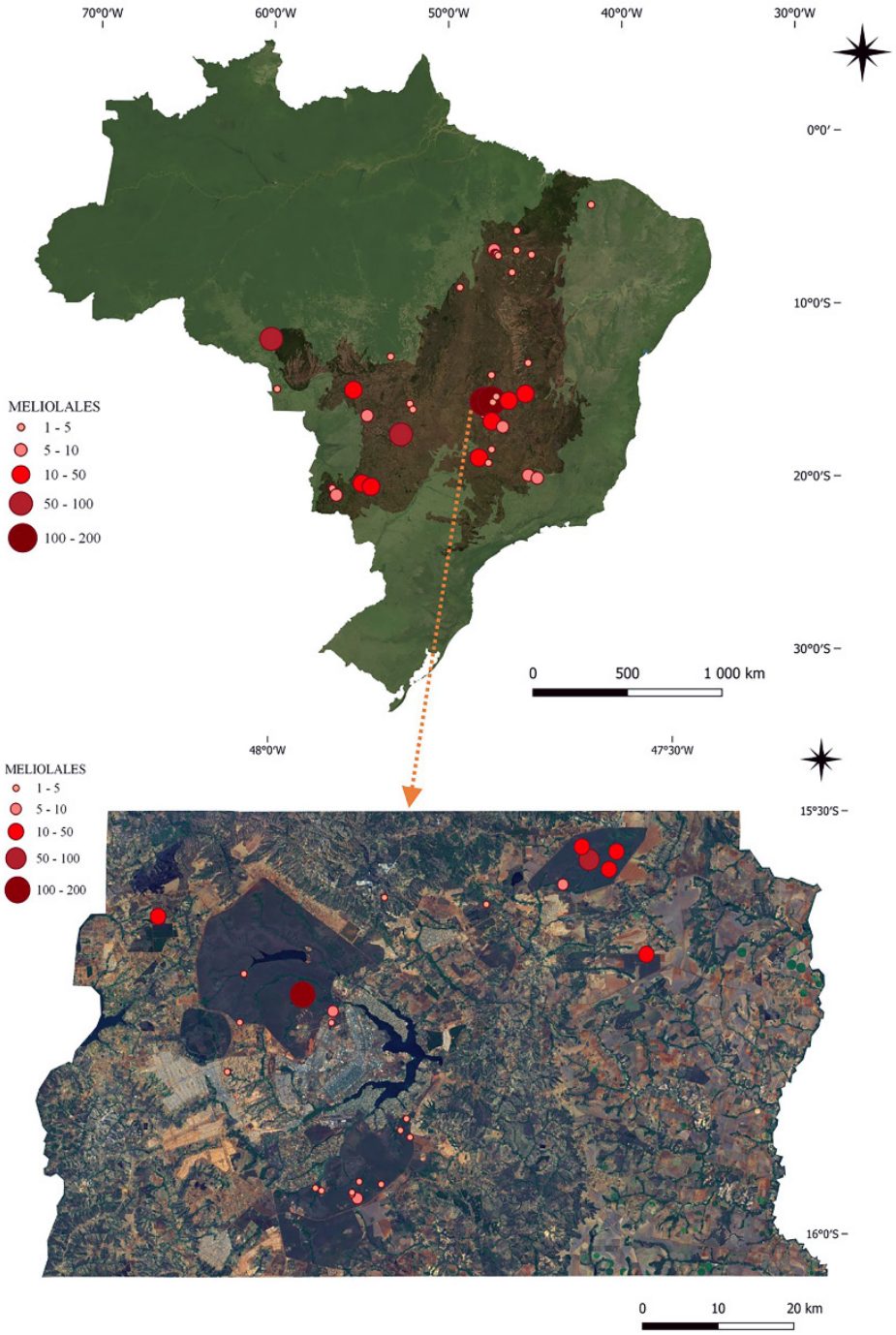

Figure 6. Collection sites in the Brazilian Cerrado (top map), and a detailed view of the activity in the Federal District (bottom), related to the 836 specimens of Meliolales incorporated into the MCHUB starting in 1993. Diameters of the circles are proportional to the number of specimens collected in each site.

vered starting with a large sample taken from the Parque dos Poderes, a permanent Cerrado Reserve, right at the downtown capital Campo Grande, Embrapa Cerrado Reserve at Lagoinha Farm, Cerrados at Terenos (Patagonia Farm and others), several sites at the Pantanal Matogrossense in Aquidauana, Bodoquena, and Miranda.

In Minas Gerais 2,294 specimens were collected covering two National Parks (Grande Sertão Veredas and Serra do Cipó), Panga Ecological Reserve (Federal University of Uberlândia), Grotadas in Santo Antônio do Monte, Cerrados around Uberlândia, Araguari, Brasília and Prata along the highways BR 050, BR 040 and MG 497, Barrinha Farm (São Sebastião do Oeste), Divinópolis, Marilândia, Pedra Grande Farm (Buritis), Botelho Puntel Farm (Paracatu), around the basins of Furnas, Miranda and Nova Ponte hydroelectric dams.

Only 106 specimens came from Piauí on a trip to the Sete Cidades National Park in Piripiri, going

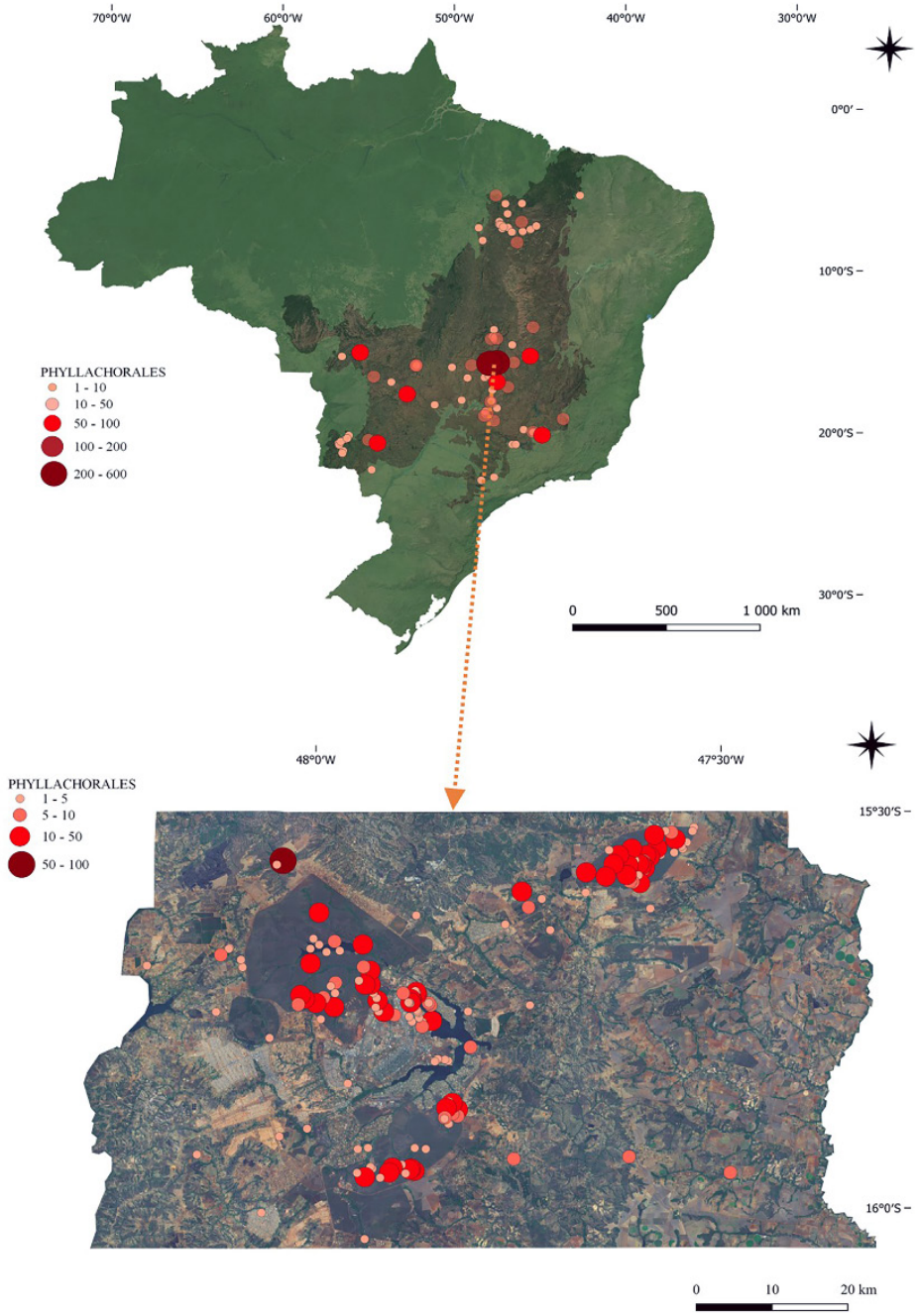

Figure 7. Collection sites in the Brazilian Cerrado (top map), and a detailed view of the activity in the Federal District (bottom), related to the 2501 specimens of Phyllachorales incorporated into the MCHUB starting in 1993. Diameters of the circles are proportional to the number of specimens collected in each site.

through Campo Maior. The State of Tocantins needs to be further surveyed, only 35 specimens from Araguaína, Pedra Branca and Gurupi.

An important historical record is to acknowledge here that over 20% of the specimens deposited in the MCHUB were collected from over 40 different sites by the late Prof. Mariza Sanchez (Figure 9), who exerted the curatorship of the Collection for over 23 years.

The rust fungi from the State of São Paulo were covered in detail by Carvalho-Junior et al. (2008), and their data was included herein. However, concerning other microfungi the Cerrado reserves from Mogi Guaçu, Mogi Mirim and Antônio Alves need to be covered by the MCHUB in the future.

Most plant-associated microfungi from the Cerrado are strictly biotrophic, and the main groups belong to Asterinales, Meliolales, Phyllachorales, and Pucciniales, or highly host specific members of the Capnodiales/ Mycosphaerellaceae (Tables 4

Figure 8. Cover pictures of the journals Plant Disease and Mycologia contributed by Agra et al. (2018) and Guterres et al. (2019) working at the MCHUB, respectively. Pictures included with permission from the American Phytopathological Society and Mycological Society of America.

Figure 9. Professor Mariza Sanchez (*1948 -†2015). MCHUB Curator- 1991 to 2014. Photo by Maryland Sanchez - 1999.

and 5). Thus, the extinction of rare or endemic plant species occurring in 50 plant families in the Cerrado (MARTINELLI et al. 2014), will also seal the destiny of many microfungal species from the second largest Brazilian biome.

The MCHUB is an internationally recognized collection that contains 148 holotypes, being 18 type species of new genera, needing care on the part of the institution administrative agents to remain as a safe repository of the Cerrado mycodiversity related to the plant-associated microfungi. Almost half of the MCHUB inventory is still to be studied, clearly showing that it is a dynamic institution where at any time researchers will be able to generate mycological knowledge from well preserved samples, mainly because now DNA extraction of herborized material became routine for most of the biotrophic microfungi.

ACKNOWLEDGMENTS

We thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico for a research grant to JCD (CNPq # 457455/2012-8) within the "2012 PPBIO-Cerrado Project". JCD thanks "Fundação Banco do Brasil" for the 1995 grant that allowed

for the assembly of the Herbarium UB Mycological Collection and provided funds for the nationwide collections throughout the Cerrado Biome mostly in National Parks, from 1995 to1998. More recently it was most welcome a grant from the Fundação de Apoio à Pesquisa do Distrito Federal (FAPDF) through the Project FAP-DF # 417 00193-077/2019-41, headed by Prof. Dirceu Macagnan.

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