

Additions to a checklist of coprophilous fungi and other fungi recorded on dung from Brazil: an overview of a century of research

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ABSTRACT—In 2014 we published the first checklist of fungi *sensu lato* recorded on dung from Brazil, as a result of an effort to maintain an easily accessible database on the knowledge of the diversity of these fungi. In the last 10 years there has been a significant increase in the number of publications involving this ecological group, and we are presenting an update which summarizes data from a century of research (from 1919 to 2019). We present an annotated list of all species and occurrences added to the Brazilian copromycodiversity, the annual accumulation of records, and occurrence by substrate. There were 302 records of 166 species, 98 of which are new for Brazil, all of them reported from seven Federation states (including two new). Most of the occurrences are reported from the northeast region of the country (Pernambuco and Piauí states), followed by the midwest (Goiás and Federal District) and southern regions (Paraná and Rio Grande do Sul). Amazonas and Piauí are states with new records of these organisms, with one record each. There are now 568 occurrences and 308 species of dung-inhabiting fungi recorded in Brazil.

KEY WORDS—dung-inhabiting fungi, new occurrences, species distribution, substrates

Introduction

In 2014, we published the first checklist of fungi *sensu lato* recorded on dung from Brazil (Calaça & al. 2014). We use the term ‘dung-inhabiting fungi’ for coprophilous/fimicolous fungi (fungi with morphological, physiological or behavioural adaptations so that their spores are consumed by animals, and grow and fruit on their dung), or saprotrophic fungi without such adaptations but which are able to grow on such nutrient rich sources as dung. The principal representatives of dung-inhabiting fungi are in the phyla Ascomycota, Basidiomycota and Mucoromycota, although many myxomycetes (Amoebozoa) and myxobacteria (Proteobacteria: Myxococcales) have been reported on this substrate (Bell 1983, Eliasson & Lundqvist 1979, Calaça & al. 2017, 2020).

Studies of dung-inhabiting fungi in Brazil have increased considerably in the last 10 years, and have included taxonomic and ecological aspects. As a result of an effort to maintain an easily accessible database on the knowledge of fungal diversity in Brazil, we present here additions to the 2014 checklist, which now includes data from a century of research/observations, from 1919 to 2019. Thus, we contribute to the increase of knowledge about this ecological group, and identify areas where there are gaps in the knowledge.

Materials & Methods

We performed an extensive review of the literature published between 2014 to 2019 related to dung-inhabiting fungi *sensu lato*, according to methods used by Calaça & al. (2014). All recorded data were compiled in spreadsheets. Nomenclature is in accordance with Mycobank (<http://www.mycobank.org/>),

Index Fungorum (<http://www.indexfungorum.org/Names/Names.asp>), and/or with the most recent literature dealing with specific taxa, e.g., families of Ascomycota with coprophilous representatives (Wijayawardene & al. 2017; He & al. 2019). For myxomycetes, we followed Lado (2020). Data on new records were checked and updated based on our first checklist (Calaça & al. 2014). The checklist was organized in alphabetical order of species in their respective phylum, order and family.

The annual increase of dung-inhabiting fungi was determined from the number of new records each year, from the first report in 1919 and the total of species presented in Calaça & al. (2014). In the checklist that follows, all species added to the Brazilian copromycodiversity are highlighted in blue. The Federation States are underlined; those states marked with an asterisk are states with dung-inhabiting fungi recorded for the first time. The updated map (from Calaça & al. 2014 to the present) shows only records with defined localities and was built using ARCGIS 10.1. Each record on each dung type is considered to be a distinct occurrence. Subsequently, we calculated the absolute total and percentage of occurrences on each dung type. Graphs and analysis were performed in both PAST 4.01 (Hammer & al. 2001) and Microsoft Excel[®].

Results and Discussion

We report 302 new occurrences (113% increase) and 166 species, 98 of which are new for Brazil (46% increase), recorded in seven Federation states (Figure 1). The records are distributed in seven phyla, 21 orders, 41 families, and 75 genera (Table 1). Ascomycota contributed to 117 species (70% of the total), followed by Mucoromycota, with 23 species (13.8%), Basidiomycota (20, 12%), Myxomycota (3, 1.8%) and Zoopagomycota, Actinobacteria and Proteobacteria, with one species each (0.6%).

Amazonas and Piauí were states with new records of these fungi. Most occurrences are in northeast Brazil, with 198 records (65.5%) and 133 species in Pernambuco and one occurrence of a single species in Piauí (0.3%). Next is the midwest region, with 76 occurrences (25%) and 38 species in Goiás and 15 (5%) occurrences and 10 species in the Federal District. The southern region (Rio Grande do Sul and Paraná) has eight species (2.6%); Rio Grande do Sul had six species and three (1%) occurrences and three species in Paraná. Finally, the north (Amazonas) has a single occurrence of one species (Figure 1B).

TABLE 1. Synopsis of taxa in the present checklist, with the respective total of species in each genus.

HIGHER TAXON	PHYLUM	ORDER	FAMILY	GENUS	SPECIES			
Fungi	Mucoromycota	Mucorales	Cunninghamellaceae	<i>Absidia</i>	1			
				<i>Cunninghamella</i>	1			
			Lichtheimiaceae	<i>Lichtheimia</i>	2			
			Mucoraceae	<i>Mucor</i>	8			
			Pilobolaceae	<i>Pilobolus</i>	6			
			Rhizopodaceae	<i>Rhizopus</i>	2			
			Syncephalastraceae	<i>Circinella</i>	1			
				<i>Syncephalastrum</i>	1			
				<i>Thamnostylum</i>	1			
				Zoopagomycota	Zoopagales	Piptocephalidaceae	<i>Syncephalis</i>	1
				Ascomycota	Cladosporiales	Cladosporiaceae	<i>Cladosporium</i>	2
					Coniochaetales	Coniochaetaceae	<i>Coniochaeta</i>	2
			Dothideales		Dothioraceae	<i>Aureobasidium</i>	1	
			Eurotiales		Aspergillaceae	<i>Aspergillus</i>	7	
						<i>Penicillium</i>	7	
						<i>Paecilomyces</i>	1	
						Trichocomaceae	<i>Talaromyces</i>	1
	Hypocreales	Bionectriaceae				<i>Mycoarachis</i>	1	
		Ceratostomataceae				<i>Melanospora</i>	2	
		Hypocreaceae	<i>Trichoderma</i>		4			
		Nectriaceae	<i>Fusarium</i>	1				
		<i>Neocosmospora</i>	1					
	Microascales	Sarocladiaceae	<i>Sarocladium</i>	1				
		Chadefaudiellaceae	<i>Faurelina</i>	2				
			Microascaceae	<i>Cephalotrichum</i>	2			
		<i>Acaulium</i>	1					
		<i>Graphium</i>	1					
		<i>Kernia</i>	1					
		<i>Lophotrichus</i>	1					
		<i>Parascedosporium</i>	1					
		<i>Pseudallescheria</i>	1					
		Pezizales	Ascobolaceae	<i>Ascobolus</i>	7			
				<i>Saccobolus</i>	8			
	Ascodesmidaceae		<i>Ascodesmis</i>	1				
			<i>Coprotus</i>	8				
	<i>Lasiobolus</i>		1					
	Pezizaceae		<i>Iodophanus</i>	1				
	Pyronemataceae		<i>Cheilymenia</i>	1				
	Pleosporales	Delitschiaceae	<i>Delitschia</i>	2				
		Sporormiaceae	<i>Preussia</i>	1				
			<i>Sporormia</i>	1				
	<i>Sporormiella</i>	6						
	Pyxidiophorales	Pyxidiophoraceae	<i>Pyxidiophora</i>	1				
		Sordariales	Chaetomiaceae	<i>Chaetomium</i>	3			
	<i>Collariella</i>			1				
	<i>Corynascus</i>		1					
	<i>Thermothielavioides</i>		1					
Lasiosphaeriaceae	<i>Arnium</i>		1					
	<i>Cercophora</i>		5					
	<i>Schizothecium</i>		1					
	<i>Triangularia</i>		2					
	<i>Zopfiella</i>		2					
	<i>Zygopleurage</i>		1					
Podosporaceae	<i>Podospora</i>	12						
Sordariaceae	<i>Sordaria</i>	2						
Thelebolales	Thelebolaceae	<i>Thelebolus</i>	1					
Xylariales	Xylariaceae	<i>Hypocopra</i>	1					
<i>Incertae sedis</i>	Monascaceae	<i>Monascus</i>	1					
	Pseudeurotiaceae	<i>Leuconeurospora</i>	1					

TABLE 1. Continued...

HIGHER TAXON	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
Fungi	Ascomycota	<i>Incertae sedis</i>	<i>Incertae sedis</i>	<i>Cephalophora</i>	1
				<i>Phaeostilbelloides</i>	1
	Basidiomycota	Agaricales	Bolbitiaceae	<i>Bolbitius</i>	1
				<i>Conocybe</i>	1
				<i>Morganella</i>	1
				<i>Coprinellus</i>	3
				<i>Coprinopsis</i>	8
				<i>Panaeolus</i>	3
				<i>Parasola</i>	1
				<i>Incertae sedis</i>	1
Protozoa	Myxomycota	Phallales	Phallaceae	<i>Lysurus</i>	1
		Liceales	Liceaceae	<i>Licea</i>	1
		Physarales	Physaraceae	<i>Physarum</i>	1
		Trichiales	Trichiaceae	<i>Arctyria</i>	1
Bacteria	Actinobacteria	Actinomycetales	<i>Incertae sedis</i>	<i>Palaeostromatus</i>	1
	Proteobacteria	Myxococcales	<i>Incertae sedis</i>	<i>Chondromyces</i>	1
3	7	21*	41*	75	166**

* *Incertae sedis* taxa were not included in count.

** 98 are new species for Brazilian copromycodiversity.

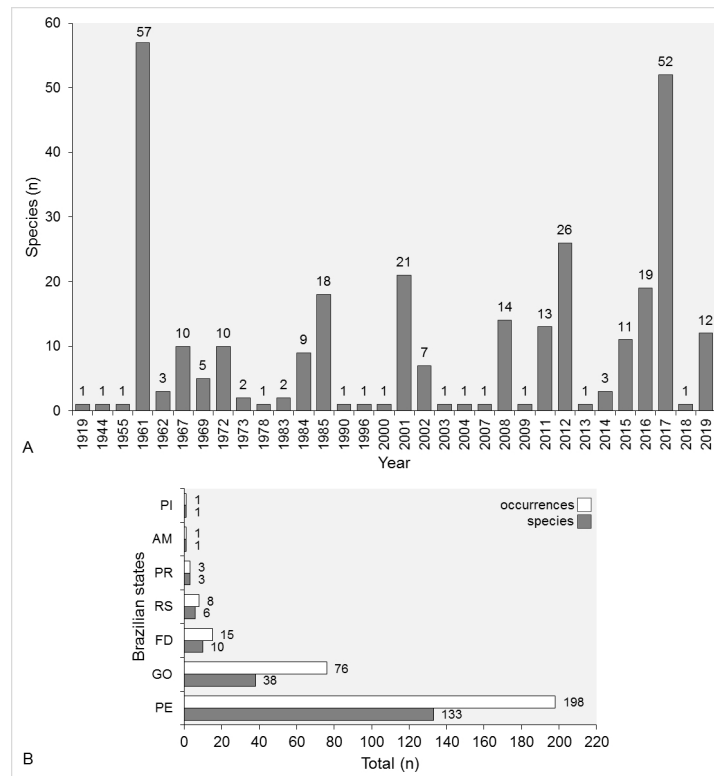


FIGURE 1. Occurrences of dung-inhabiting fungi *sensu lato* in Brazil in the last 100 years. A: Number of new species added per year, from 1919 to 2019, according to Calaça & al. (2014) and this paper. B: Number of species and occurrences, from 2014 to 2019, by state. (PE = Pernambuco, GO = Goiás, FD = Federal District, RS = Rio Grande do Sul, PR = Paraná, AM = Amazonas, PI = Piauí).

From the 16 substrates (i.e., dung type) found, eight are from domestic animals: cattle, horse, goat, sheep, pig, donkey, guinea fowl, and rabbit. The remaining are from wild animals (capybara, white-lipped peccary, brown-brocket deer, camel, llama, deer, guinea pig, and rock cavy). Two mentioned substrates were not inserted in any classes, once they represent three occurrences on undefined dung type and one occurrence

to fossilized dung (i.e., coprolite), found in the outcrop "Coproland", deposited during the Carboniferous–Early Triassic interval, where today is located the São Gabriel municipality, state of Rio Grande do Sul, southern Brazil. According to the authors, a carnivorous fish produced the coprolite (Dentzien-Dias & al. 2016). Of the 302 occurrences, 81 (27%) were in cattle dung, 79 (26%) in horse dung, 72 (24%) on goat, 17 (6%) on sheep and 10 (3%) on both capybara and pig dung. The remaining 33 occurrences (14%) were from the other substrates (Figure 2). The majority of occurrences (88%) were on dung of domestic animals. This high occurrence on the dung of domesticated animals is probably due to the ease of collecting this substrate, rather than that of wild animals. Thus, we highlight the importance of investigating copromycodiversity in the dung of wild animals for the screening of the fungi associated with them. Studies focused on this dung type may reveal the indigenous dung-inhabiting fungal communities in a given ecosystem. Brazilian dung-inhabiting fungi now total 568 records (including 15 with no locality recorded) and 308 species.

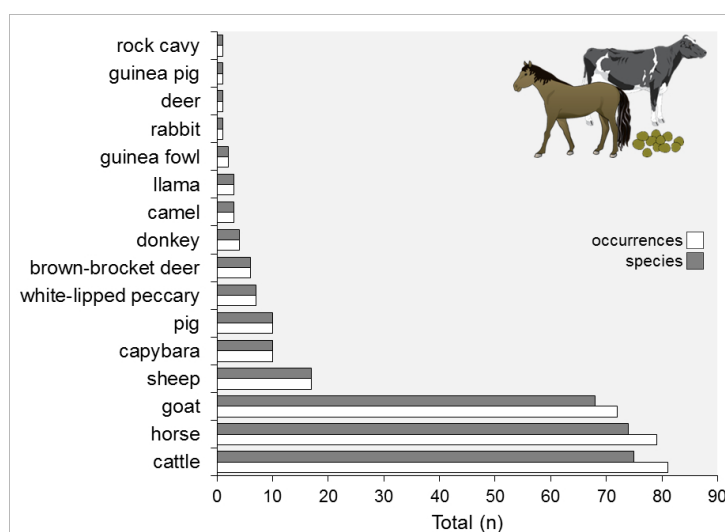


FIGURE 2. Occurrence of dung inhabiting fungi on different dung types.

Professor Augusto Chaves Batista (1916–67), from University of Recife (now Federal University of Pernambuco) contributed many records of dung-inhabiting yeasts, especially in 1961, and by sending samples to eminent dung fungi mycologists, such as Nils Lundqvist (1930–2017) (da Silva & Minter 1995, Calaça & al. 2014). Not until 1985 do we see an increase in records of dung-inhabiting fungi (Mucorales) from Brazil, with the contributions of Professor Sandra Farto Botelho Trufem and her student at that time, Airton Viriato (Trufem & Viriato 1985, Viriato & Trufem 1985a,b). In 2001, the first work with an ecological approach was also published, developed by the British mycologist Michael J. Richardson, with samples collected in the state of Mato Grosso do Sul, during a visit to Brazil in 1998 (Richardson 2001). Today, this is a classic and important contribution for the group in Brazil. In the last 10 years there has been a considerable increase in the number of studies of dung-inhabiting fungi (Figure 3).

Until 2010, articles with records of dung-inhabiting fungi in Brazil were few and most of the records have been published since 2000. We highlight the publication of the first Brazilian study on the occurrence of fimicolous myxomycetes (Bezerra & al. 2008), in areas of Caatinga, northeast Brazil, in states of Pernambuco and Sergipe. The Brazilian mycologists Vagner Gularte Cortez and Felipe Wartchow, for the south and north regions of the country, respectively, made other important records, contributing to the

knowledge of dung-inhabiting agarics in the Strophariaceae (see Cortez & Coelho 2004, Guzmán & Cortez 2004, Cortez & Silveira 2008). For Mucoromycota, important contributions came from André Luiz C. M. A. Santiago, then a doctorate student under the guidance of Professor Maria Auxiliadora de Queiroz Cavalcanti (Santiago & al. 2008a,b, 2009).

Unfortunately, there is a significant lack of trained mycologists working with dung-inhabiting fungi in Brazil. Currently, only a small group of mycologists at the University of Goiás State (UEG) and the Federal University of Pernambuco (UFPE) carry out the main research on the group. In midwestern Brazil (Goiás and Federal District), Francisco J. Simões Calaça published the pioneering articles on dung-inhabiting fungi in the Brazilian Cerrado, at the University of Goiás State, during his undergraduate studies, under the guidance of Professor Solange Xavier dos Santos. These studies contributed to the knowledge of copromycodiversity in central Brazil, specifically in Goiás and the Federal District. The authors also compiled and published the first list of species (Calaça & al. 2014), and the first book dealing specifically with dung-inhabiting fungi in Brazil, the result of research carried out from 2010 to 2016 (Calaça & Xavier-Santos 2017). Roger F. Ribeiro Melo, then a master's student, under the guidance of Professor Maria Auxiliadora de Queiroz Cavalcanti, and then during his doctoral studies, under the guidance of Professor Leonor Costa Maia, at the Federal University of Pernambuco, made important contributions to the knowledge of dung-inhabiting fungi, especially ascomycetes, in the Caatinga and Atlantic Forest biomes. These researchers have contributed most of the recent records/studies of dung-inhabiting fungi in Brazil, from 2011 to the present (Figure 3).

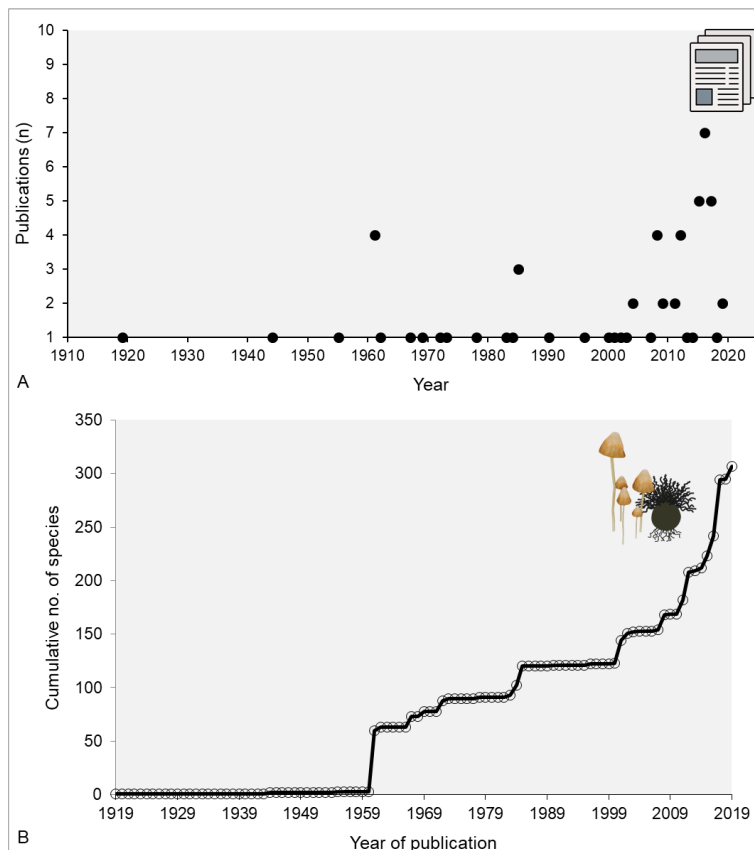


FIGURE 3. A: Publications with occurrences of dung-inhabiting fungi *sensu lato* in Brazil in the 100 years from 1919 – 2019. B: Cumulative number of dung-inhabiting species added per year in Brazil.

The relatively few studies in such a big country emphasises the need for mycologists to study these fungi, as Brazil still has many under- or un-explored areas, even after a century of research (Figure 4). There are still many areas with little or no data on the occurrence of these organisms, to which more efforts to studies and human resources training in Mycology should be directed. Additionally, we reinforce the importance of publishing species lists (i.e., checklists), which provide knowledge of the distribution of dung-inhabiting fungi, with its main importance in the nutrient cycling in terrestrial ecosystems. The publication of recent lists, at global and national scale (e.g., Amandeep & al. 2015; 2019, Richardson 2015; 2019, Abdel-Azeem & Salem 2015) allows us to evaluate the distribution of these fungi, to view hot spots of occurrence of certain groups, substrates, endemism, etc. These broad datasets may interest mycologists who study aspects of the biology, ecology, and evolution of the group, and direct attention to ecosystems little or not studied, as in Brazil.

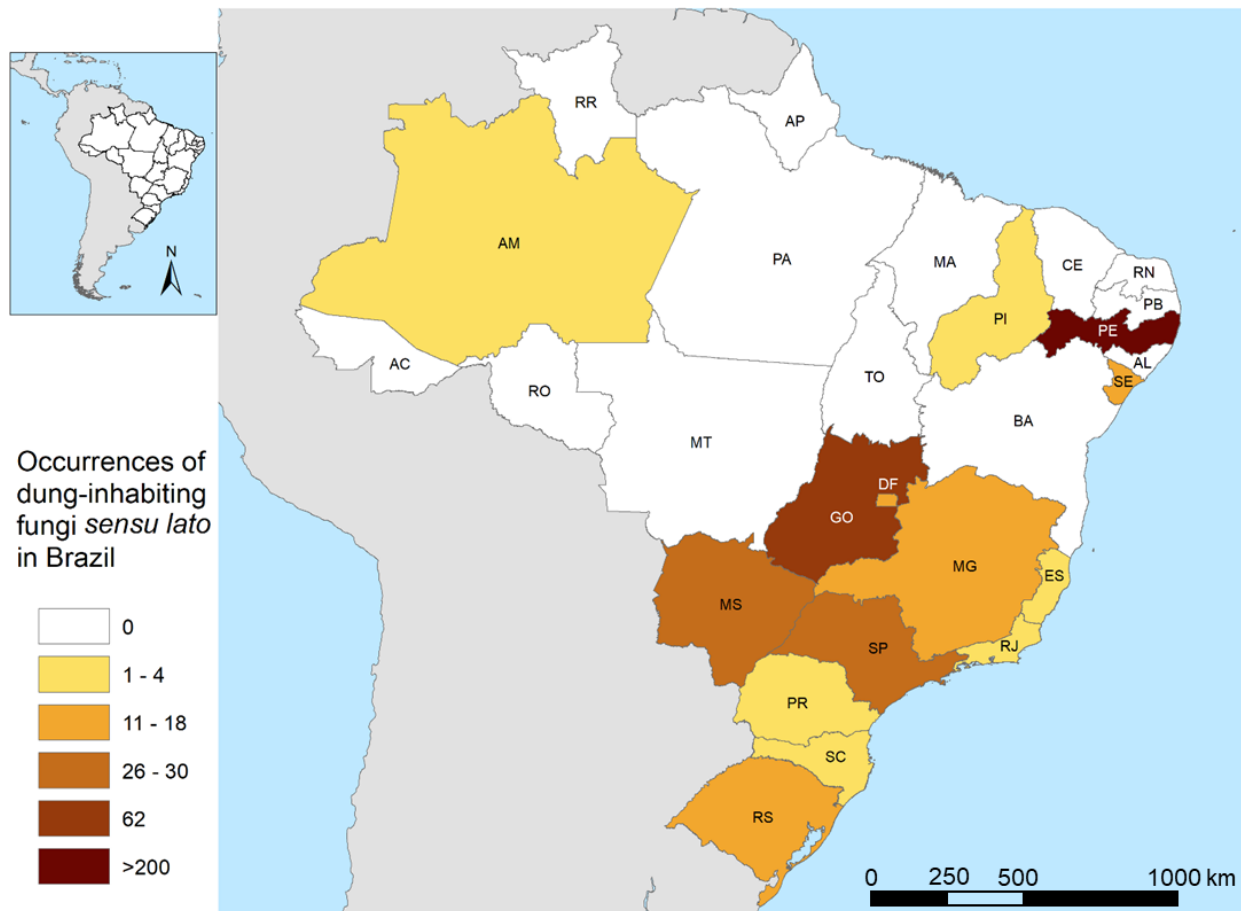


FIGURE 4. Location of the area covered in this study: A. Brazil in South America. B. Occurrences of dung-inhabiting fungi *sensu lato* in states of Brazil, from 1919 to 2019. For Brazilian state acronyms, see https://en.wikipedia.org/wiki/States_of_Brazil.

The additions to the checklist follow. Species added after Calaça & al. (2014) are highlighted in blue:

Additions to the checklist of records of coprophilous and other fungi *sensu lato* in Brazil

Fungi R.T. Moore

Mucoromycota Doweld

Mucorales Dumort.

Cunninghamellaceae Naumov ex R.K. Benj.

Absidia cylindrospora Hagem

Pernambuco, as *A. cylindrospora* var. *cylindrospora* Hagem, on cattle (*Bos taurus* L.) dung (Souza & al. 2017).

Cunninghamella echinulata (Thaxt.) Thaxt. ex Blakeslee

Pernambuco, as *C. echinulata* var. *echinulata* (?), on cattle dung (Souza & al. 2017).

Lichtheimiaceae Kerst. Hoffm., Walther & K. Voigt

Lichtheimia brasiliensis A.L. Santiago, N. Lima & R.J.V. Oliveira

Pernambuco, on sheep (*Ovis aries* L.) dung (Souza & al. 2017).

Lichtheimia ramosa (Zopf) Vuill.

Pernambuco, on sheep and goat (*Capra hircus* L.) dung (Souza & al. 2017).

Mucoraceae Fr.

Mucor circinelloides Tiegh.

Pernambuco, as *M. circinelloides* f. *circinelloides* Tiegh., *M. circinelloides* f. *griseocyanus* (Hagem) Schipper and *M. circinelloides* f. *janssenii* (Lendn.) Schipper, on goat, cattle and sheep dung (Souza & al. 2017).

Mucor hiemalis Wehmer

Pernambuco, on sheep dung (Souza & al. 2017).

Mucor indicus Lendn.

Pernambuco, on goat dung (Souza & al. 2016). On sheep and goat dung (Souza & al. 2017).

Mucor lusitanicus Bruderl.

Pernambuco, on sheep and cattle dung (Souza & al. 2017).

Mucor luteus Linnem.

Pernambuco, on cattle, goat and sheep dung (Souza & al. 2017).

Mucor racemosus Fresen.

Pernambuco, as *M. racemosus* f. *racemosus* Fresen., on cattle dung (Souza & al. 2017).

Mucor ramosissimus Samouts.

Pernambuco, on cattle, goat and sheep dung (Souza & al. 2017).

Mucor variosporus Schipper

Pernambuco, on sheep dung (Souza & al. 2017).

Pilobolaceae Corda

Pilobolus crystallinus (F.H. Wigg.) Tode

Pernambuco, on cattle and goat dung (Souza & al. 2017).

Goiás, on capybara (*Hydrochoerus hydrochaeris* L.), goat and horse dung (Calaça & Xavier-Santos 2017).

Federal District, on brown-brocket deer (*Mazama gouazoubira* Fisher) and horse dung (Calaça & Xavier-Santos 2017).

Pilobolus kleinii Tiegh.

Pernambuco, on cattle, goat and sheep dung (Souza & al. 2017).

Goiás, on capybara and cattle dung (Calaça & Xavier-Santos 2017).

Pilobolus longipes Tiegh.

Pernambuco, on cattle, goat and sheep dung (Souza & al. 2017).

Pilobolus minutus Speg.

Pernambuco, as *P. minutus* R.Y. Zheng & G.Q. Chen, on cattle dung (Souza & al. 2017).

Pilobolus morinii Sacc. & D. Sacc.

Goiás, on pig (*Sus domesticus* L.) and guinea fowl (*Numida meleagris* L.) dung (Calaça & Xavier-Santos 2017).

Pilobolus oedipus Mont.

Pernambuco, on cattle, goat and sheep dung (Souza & al. 2017).

Rhizopodaceae K. Schum.

Rhizopus arrhizus A. Fisch.

Pernambuco, as *R. arrhizus* var. *arrhizus* A. Fisch., on sheep dung (Souza & al. 2017).

Rhizopus stolonifer (Ehrenb.) Vuill.

Pernambuco, on sheep dung (Souza & al. 2017).

Syncephalastraceae Naumov ex R.K. Benj.

Circinella muscae (Sorokīn) Berl. & De Toni

Pernambuco, on cattle, goat and sheep dung (Souza & al. 2017).

Syncephalastrum racemosum Cohn ex J. Schröt.

Pernambuco, on cattle, goat and sheep dung (Souza & al. 2017).

Thamnostylum piriforme (Bainier) Arx & H.P. Upadhyay

Goiás, on white-lipped peccary (*Tayassu pecari* Link) dung (Calaça & Xavier-Santos 2017).

Zoopagomycota Gryganskyi, M.E. Sm., Spatafora & Stajich**Zoopagales** Bessey ex R.K. Benj.

Piptocephalidaceae Sred.

Syncephalis obliqua H.M. Ho & Benny

Pernambuco, on horse (*Equus caballus* L.) dung (Melo & al. 2015c).

Ascomycota Caval.-Sm.

Cladosporiales Abdollahz. & Crous

Cladosporiaceae Chalm. & R.G. Archibald

Cladosporium cf. *cladosporioides* (Fresen.) G.A. de Vries
Pernambuco, on goat dung (Melo & al. 2017b).

Cladosporium oxysporum Berk. & M.A. Curtis
Pernambuco, on goat dung (Melo & al. 2017b).

Coniochaetales Huhndorf, A.N. Mill. & F.A. Fernández

Coniochaetaceae Malloch & Cain

Coniochaeta philocoproides (Griffiths) Cain
Pernambuco, on horse dung (Melo & al. 2019).

Coniochaeta lignicola (Nannf.) Z.U. Khan, Gené & Guarro
= *Lecythophora lignicola* Nannf.
Pernambuco, on cattle and horse dung (Melo & al. 2017b).

Dothideales Lindau

Dothioraceae Theiss. & Syd.

Aureobasidium pullulans (de Bary & Löwenthal) G. Arnaud
Pernambuco, on horse dung (Melo & al. 2017b).

Eurotiales G.W. Martin ex Benny & Kimbr.

Aspergillaceae Link

Aspergillus cf. *flavus* Link
Pernambuco, on goat and horse dung (Melo & al. 2017b).

Aspergillus cf. *fumigatus* Fresen.
Pernambuco, on cattle dung (Melo & al. 2017b).

Aspergillus cf. *japonicus* Saito
Pernambuco, on goat and horse dung (Melo & al. 2017b).

Aspergillus cf. *niger* Tiegh.
Pernambuco, on horse dung (Melo & al. 2017b).

Aspergillus cf. *niveus* Blochwitz
Pernambuco, on goat dung (Melo & al. 2017b).

Aspergillus cf. *parasiticus* Speare
Pernambuco, on goat dung (Melo & al. 2017b).

Aspergillus cf. *terreus* Thom
Pernambuco, on goat, cattle and horse dung (Melo & al. 2017b).

Paecilomyces cf. *variotii* Bainier

Pernambuco, on horse and goat dung (Melo & al. 2017b).

Penicillium cf. *chrysogenum* Thom

Pernambuco, on cattle and horse dung (Melo & al. 2017b).

Penicillium cf. *citrinum* Thom

Pernambuco, on cattle dung (Melo & al. 2017b).

Penicillium cf. *corylophilum* Dierckx

Pernambuco, on cattle and horse dung (Melo & al. 2017b).

Penicillium cf. *janczewskii* K.W. Zalessky

Pernambuco, on horse dung (Melo & al. 2017b).

Penicillium cf. *oxalicum* Currie & Thom

Pernambuco, on cattle and horse dung (Melo & al. 2017b).

Penicillium cf. *raistrickii* G. Sm.

Pernambuco, on cattle and horse dung (Melo & al. 2017b).

Penicillium cf. *waksmanii* K.M. Zalessky

Pernambuco, on horse dung (Melo & al. 2017b).

Trichocomaceae E. Fisch.

Talaromyces purpureogenus Samson, N. Yilmaz, Houbraken, Spierenb., Seifert, Peterson, Varga & Frisvad

Pernambuco, on horse dung (Melo & al. 2017b).

Hypocreales Lindau

Bionectriaceae Samuels & Rossman

Mycoarachis inversa Malloch & Cain

Pernambuco, on cattle dung (Melo & al. 2017a).

Ceratostomataceae G. Winter

Melanospora damnosa (Sacc.) Lindau

Pernambuco, on goat dung (Melo & al. 2017a).

Melanospora zamiae Corda

Pernambuco, on goat dung (Melo & al. 2017a).

Hypocreaceae De Not.

Trichoderma cf. *aureoviride* Rifai

Pernambuco, on goat, horse and cattle dung (Melo & al. 2017b).

Trichoderma cf. *harzianum* Rifai

Pernambuco, on goat dung (Melo & al. 2017b).

Trichoderma cf. *ovalisporum* Samuels & Schroers

Pernambuco, on horse dung (Melo & al. 2017b).

Trichoderma cf. pseudokoningii Rifai

Pernambuco, on goat dung (Melo & al. 2017b).

Nectriaceae Tul. & C. Tul.

Fusarium oxysporum Schldl. (*species complex*)

Pernambuco, on goat and cattle dung (Melo & al. 2017b).

Neocosmospora solani (Mart.) L. Lombard & Crous

Pernambuco, as *Fusarium solani* (Mart.) Sacc. *species complex*, on goat and cattle dung (Melo & al. 2017b).

Sarocladiaceae L. Lombard

Sarocladium bacillisporum (Onions & G.L. Barron) Summerb.

Pernambuco, on cattle dung (Melo & al. 2017b).

Microascales Luttr. ex Benny & R.K. Benj.

Chadefaudiellaceae Faurel & Schotter ex Benny & Kimbr.

Faurelina fimigena Locq.-Lin.

Pernambuco, on cattle dung (Melo & al. 2016b).

Faurelina hispanica Valldos. & Guarro

Pernambuco, on horse dung (Melo & al. 2016b).

Microascaceae Luttr. ex Malloch

Acaulium retardatum (Udagawa & T. Muroi) Lei Su, in Su, Zhu, Niu, Guo, Du, Guo, Zhang & Qin
= *Kernia retardata* Udagawa & T. Muroi

Goiás, goat, pig and rabbit (*Oryctolagus cuniculus* Lilljeborg) dung (Calaça & Xavier-Santos 2017).

Cephalotrichum cylindricum (Clem. & Shear) S.P. Abbott

Pernambuco, as *Trichurus cylindricus* Clem. & Shear, on goat dung (Melo & al. 2017b).

Cephalotrichum purpureofuscum (S. Hughes) S. Hughes

Pernambuco, on goat dung (Melo & al. 2017b).

Graphium penicillioides Corda

Pernambuco, on goat, horse and cattle dung (Melo & al. 2017b).

Kernia nitida (Sacc.) Nieuwl.

Pernambuco, on goat dung (Melo & al. 2017a).

Lophotrichus bartlettii (Masse & E.S. Salmon) Malloch & Cain

Pernambuco, on goat dung (Melo & al. 2017a).

Parascedosporium putredinis (Corda) Lackner & de Hoog

Pernambuco, on goat, horse and cattle dung (Melo & al. 2017b).

Pseudallescheria boydii (Shear) McGinnis, A.A. Padhye & Ajello

Pernambuco, on goat and cattle dung (Melo & al. 2017a).

Pezizales J. Schröt.

Ascobolaceae Boud. ex Sacc.

Ascobolus americanus (Cooke & Ellis) SeaverPernambuco, on cattle, goat and horse dung (Melo & al. 2014).*Ascobolus castaneus* TengPernambuco, on horse dung (Melo & al. 2019).*Ascobolus crenulatus* P. Karst.Pernambuco, on goat dung (Melo & al. 2014).*Ascobolus elegans* J. KleinPernambuco, on horse dung (Melo & al. 2014).*Ascobolus immersus* Pers.Pernambuco, on cattle and horse dung (Melo & al. 2014).Goiás, on capybara, cattle and horse dung (Calaça & Xavier-Santos 2017).Federal District, on brown-brocket deer dung (Calaça & Xavier-Santos 2017).*Ascobolus immersus* Pers.=*Ascobolus immersus* var. *andinus* Pers.Goiás, on cattle dung (Calaça & Xavier-Santos 2017).*Ascobolus scatigenus* (Berk. & M.A. Curtis) Brumm.Pernambuco, on cattle dung (Melo & al. 2014).Goiás, on cattle and horse dung (Calaça & Xavier-Santos 2017).*Saccobolus beckii* HeimerlPernambuco, on goat dung (Melo & al. 2014).*Saccobolus citrinus* Boud. & TorrendPernambuco, on cattle and goat dung (Melo & al. 2014).Goiás, on capybara, donkey (*Equus asinus* L.), cattle and horse dung (Calaça & Xavier-Santos 2017).*Saccobolus depauperatus* (Berk. & Broome) E.C. HansenPernambuco, on cattle and goat dung (Melo & al. 2014).Goiás, on horse dung (Calaça & Xavier-Santos 2017)*Saccobolus glaber* (Pers.) LambottePernambuco, on cattle and horse dung (Melo & al. 2014).Goiás, on capybara and horse dung (Calaça & Xavier-Santos 2017).*Saccobolus infestans* (Bat. & Pontual) Brumm.Pernambuco, on horse dung (Melo & al. 2014).*Saccobolus minimus* Velen.Pernambuco, on goat dung (Melo & al. 2014).*Saccobolus saccoboloides* (Seaver) Brumm.Pernambuco, on goat dung (Melo & al. 2014).Goiás, on goat dung (Calaça & Xavier-Santos 2017).

Saccobolus truncatus Velen.

Pernambuco, on cattle dung (Melo & al. 2014).

Ascodesmidaceae J. Schröt.

Ascodesmis nigricans Tiegh.

Goiás, on pig and white-lipped peccary dung (Calaça & Xavier-Santos 2017).

Coprotus albidus (Boud.) Kimbr.

Rio Grande do Sul, on horse dung (Melo & al. 2019).

Coprotus aurora (P. Crouan & H. Crouan) K.S. Thind & Waraitch

Pernambuco, on goat dung (Melo & al. 2015b).

Coprotus disculus Kimbr., Luck-Allen & Cain

Pernambuco, on goat and horse dung (Melo & al. 2015b).

Coprotus lacteus (Cooke & W. Phillips) Kimbr., Luck-Allen & Cain

Pernambuco, on goat and horse dung (Melo & al. 2015b).

Coprotus leucopocillum Kimbr., Luck-Allen & Cain

Pernambuco, on goat, camel, cattle and horse dung (Melo & al. 2015b).

Coprotus luteus Kimbr.

Pernambuco, on horse dung (Melo & al. 2015b).

Coprotus niveus (Fuckel) Kimbr., Luck-Allen & Cain

Pernambuco, on camel dung (Melo & al. 2015b).

Coprotus ochraceus (P. Crouan & H. Crouan) J. Moravec

Pernambuco, on horse and cattle dung (Melo & al. 2015b).

Lasiobolus papillatus (Pers.) Sacc.

=*Lasiobolus ciliatus* (J.C. Schmidt) Boud.

Goiás, on white-lipped peccary dung (Calaça & Xavier-Santos 2017).

Pezizaceae Dumort.

Iodophanus carneus (Pers.) Korf

Goiás, on cattle dung (Calaça & Xavier-Santos 2017).

Pyronemataceae Corda

Cheilymenia granulata (Bull.) J. Moravec

Goiás, on horse and cattle dung (Calaça & Xavier-Santos 2017).

Pleosporales Luttr. ex M.E. Barr

Delitschiaceae M.E. Barr

Delitschia gigaspora Cain

= *Delitschia gigaspora* var. *pescanensis* Calaça, Xav.-Sant. & Delpont

Goiás, on cattle dung (Calaça & al. 2015).

Delitschia vulgaris Griffiths

Pernambuco, on horse dung (Melo & al. 2019).

Sporormiaceae Munk

Preussia fleischhakkii (Auersw.) Cain

Federal District, on horse dung (Calaça & Xavier-Santos 2017).

Sporormia pentamera (Oudem.) S.I. Ahmed & Cain

= *Sporormiella pentamera* Oudem.

Pernambuco, on horse dung (Melo & al. 2017c).

Sporormiella australis (Speg.) S.I. Ahmed & Cain

Pernambuco, on cattle dung (Melo & al. 2017c).

Sporormiella herculea (Ellis & Everh.) S.I. Ahmed & Cain

Pernambuco, on horse dung (Melo & al. 2017c).

Sporormiella isomera S.I. Ahmed & Cain

Pernambuco, on camel (*Camelus bactrianus* L.) dung (Melo & al. 2017c).

Sporormiella leporina (Niessl) S.I. Ahmed & Cain

Pernambuco, on llama dung (Melo & al. 2017c).

Sporormiella longicolla R.F.R. Melo

Pernambuco, on horse dung (Melo & al. 2017c).

Sporormiella minima (Auersw.) S.I. Ahmed & Cain

Pernambuco, on llama and guinea pig (*Cavia porcellus* L.) dung (Melo & al. 2017c).

Goiás, on pig, horse and cattle dung (Calaça & Xavier-Santos 2017).

Federal District, on brown-brocket deer and capybara dung (Calaça & Xavier-Santos 2017).

Pyxidiophorales P.F. Cannon

Pyxidiophoraceae G.R.W. Arnold

Pyxidiophora arvernensis (Breton & Faurel) N. Lundq.

Goiás, on white-lipped peccary and cattle dung (Calaça & Xavier-Santos 2016).

Sordariales Chadeff. ex D. Hawksw. & O.E. Erikss.

Chaetomiaceae G. Winter

Chaetomium citrinum Udagawa & T. Muroi

Pernambuco, on goat dung (Melo & al. 2019).

Chaetomium cochliodes Palliser

Pernambuco, on goat dung (Melo & al. 2019).

Goiás, on pig, white-lipped peccary and goat dung (Calaça & Xavier-Santos 2017).

Federal District, on horse dung (Calaça & Xavier-Santos 2017).

Chaetomium spirale Zopf

Pernambuco, on goat dung (Melo & al. 2019).

Collariella bostrychodes (Zopf) X. Wei Wang & Samson
 = *Chaetomium bostrychodes* Zopf
Goiás, on pig and white-lipped peccary dung (Calaça & Xavier-Santos 2017).

Corynascus sepedonium (C.W. Emmons) Arx
Pernambuco, on goat dung (Melo & al. 2017a).

Thermothielavioides terrestris (Apinis) X. Wei Wang & Houbraken
 = *Thielavia terrestris* (Apinis) Malloch & Cain
Pernambuco, on goat dung (Melo & al. 2017a).

Lasiosphaeriaceae Nannf.

Arnium hirtum (E.C. Hansen) N. Lundq. & J.C. Krug
Pernambuco, on goat dung (Melo & al. 2019).

Cercophora anisura N. Lundq.
Pernambuco, on horse dung (Melo & al. 2019).

Cercophora coprophila (Fr.) N. Lundq.
Goiás, on cattle dung (Calaça & Xavier-Santos 2017).

Cercophora coronata (Cailleux) Udagawa & T. Muroi
Goiás, on horse dung (Calaça & Xavier-Santos 2016).

Cercophora pakistani (J.H. Mirza) Arx
Pernambuco, as *Tripterospora pakistani* (J.H. Mirza) Malloch & Cain, on horse dung (Melo & al. 2017a).

Cercophora sordarioides (Speg.) N. Lundq.
Pernambuco, on horse dung (Melo & al. 2019).

Schizothecium conicum (Fuckel) N. Lundq.
Goiás, on pig dung (Calaça & Xavier-Santos 2017).

Triangularia longicaudata (Cain) X. Wei Wang & Houbraken
 = *Zopfiella longicaudata* (Cain) Arx
Pernambuco, on horse dung (Melo & al. 2017a).

Triangularia pauciseta (Ces.) X. Wei Wang & Houbraken
Pernambuco, as *Podospora pauciseta* (Ces.) Traverso, on horse and cattle dung (Melo & al. 2015a).
Goiás, as *P. pauciseta*, on horse and goat dung (Calaça & Xavier-Santos 2017).
Federal District, as *P. pauciseta*, on capybara dung (Calaça & Xavier-Santos 2017).

Zopfiella erostrata (Griffiths) Udagawa & Furuya
Pernambuco, on horse and cattle dung (Melo & al. 2017a).

Zopfiella latipes (N. Lundq.) Malloch & Cain
Goiás, on pig dung (Calaça & Xavier-Santos 2016).

Zygopleurage zygospora (Speg.) Boedijn
Goiás, on capybara, horse and goat dung (Calaça & Xavier-Santos 2017).

Podosporaceae X. Wei Wang & Houbraken

Podospora appendiculata (Auersw. ex Niessl) Niessl
Pernambuco, on horse and cattle dung (Melo & al. 2015a).

Podospora australis (Speg.) Niessl
Pernambuco, on goat dung (Melo & al. 2015a).

Podospora communis (Speg.) Niessl
Pernambuco, on cattle dung (Melo & al. 2015a).
Goiás, on horse, donkey, goat and cattle dung (Calaça & Xavier-Santos 2017).

Podospora curvicolla (G. Winter) Niessl
Pernambuco, on horse dung (Melo & al. 2015a).
Goiás, on cattle dung (Calaça & Xavier-Santos 2017).
Federal District, on brown-brocket deer dung (Calaça & Xavier-Santos 2017).

Podospora decipiens (G. Winter ex Fuckel) Niessl
Pernambuco, on goat dung (Melo & al. 2015a).

Podospora fimiseda (Ces. & De Not. ex Fuckel) Niessl
Pernambuco, on horse dung (Melo & al. 2015a).
Goiás, on cattle and horse dung (Calaça & Xavier-Santos 2017).

Podospora globosa (Masse & E.S. Salmon) Cain
Pernambuco, on llama (*Lama glama* L.) and deer (Cervidae) dung (Melo & al. 2015a).

Podospora inflatula Cain
Pernambuco, on horse dung (Melo & al. 2015a).

Podospora longicaudata (Griffiths) Cain
Pernambuco, on goat dung (Melo & al. 2015a).

Podospora ostlingospora Cain
Pernambuco, on horse dung (Melo & al. 2015a).

Podospora pleiospora (G. Winter) Niessl
Pernambuco, on horse dung (Melo & al. 2015a).

Podospora prethopodalis Cain
Pernambuco, on horse and goat dung (Melo & al. 2015a).

Sordariaceae G. Winter

Sordaria lappae Potebnia
Pernambuco, on horse dung (Melo & al. 2019).

Sordaria fimicola (Roberge ex Desm.) Ces. & De Not.
Goiás, on capybara, horse, cattle and white-lipped peccary dung (Calaça & Xavier-Santos 2017).
Federal District, on brown-brocket deer dung (Calaça & Xavier-Santos 2017).

Thelebolales Haeckel

Thelebolaceae Engl.

Thelebolus microsporus (Berk. & Broome) Kimbr.

Pernambuco, on horse, cattle and goat dung (Melo & al. 2019).

Xylariales Nannf.

Xylariaceae Tul. & C. Tul.

Hypocopra stercoraria (Sowerby) Fuckel

= *Hypocopra stercoraria* (Sowerby) Sacc.

Goiás, on cattle dung (Calaça & Xavier-Santos 2016).

Incertae sedis in Ascomycota

Monascaceae J. Schröt.

Monascus ruber Tiegh.

Pernambuco, on cattle dung (Melo & al. 2017a).

Pseudeurotiaceae Malloch & Cain

Leuconeurospora pulcherrima (G. Winter) Malloch & Cain

Pernambuco, on goat dung (Melo & al. 2017a).

Incertae sedis

Cephalophora tropica Thaxt.

Pernambuco, on goat dung (Melo & al. 2017b).

Phaeostilbelloides velloziae Armando, Z.M. Chaves & Dianese

Pernambuco, on cattle dung (Melo & al. 2017b).

Basidiomycota R.T. Moore

Agaricales Underw.

Bolbitiaceae Singer

Bolbitius demangei (Quél.) Sacc. & D. Sacc.

Pernambuco, on cattle dung (Melo & al. 2016).

Conocybe siliginea (Fr.) Kühner

Pernambuco, on goat dung (Melo & al. 2016).

Lycoperdaceae Chevall.

Morganella afra Kreisel & Dring

Rio Grande do Sul, on soil among cow (cattle) dung (Trierweiler-Pereira & al. 2018).

Psathyrellaceae Vilgalys, Moncalvo & Redhead

Coprinellus angulatus (Peck) Redhead, Vilgalys & Moncalvo

Pernambuco, on horse and cattle dung (Melo & al. 2016).

Coprinellus heptemerus (M. Lange & A.H. Sm.) Vilgalys, Hopple & Jacq. Johnson

Goiás, on cattle dung (Calaça & Xavier-Santos 2017).

Federal District, on capybara dung (Calaça & Xavier-Santos 2017).

Coprinellus marculentus (Britzelm.) Redhead, Vilgalys & Moncalvo

Pernambuco, on horse and cattle dung (Melo & al. 2016).

Coprinopsis cinerea (Schaeff.) Redhead, Vilgalys & Moncalvo

Pernambuco, on horse and goat dung (Melo & al. 2016).

Coprinopsis cothurnata (Godey) Redhead, Vilgalys & Moncalvo

Pernambuco, on cattle dung (Melo & al. 2016).

Coprinopsis foetidella (P.D. Orton) A. Ruiz & G. Muñoz

Pernambuco, as *Coprinus foetidellus* P.D. Orton, on cattle dung (Melo & al. 2016).

Coprinopsis nivea (Pers.) Redhead, Vilgalys & Moncalvo

Goiás, on goat, donkey and horse dung (Calaça & Xavier-Santos 2017).

Coprinopsis patouillardii (Qué.) Gminder

Pernambuco, as *Coprinus patouillardii* Qué., on horse, goat and cattle dung (Melo & al. 2016).

Goiás, on goat, donkey, horse and cattle dung (Calaça & Xavier-Santos 2017).

Federal District, on brown-brocket deer dung (Calaça & Xavier-Santos 2017).

Coprinopsis pseudoradiata (Kühner & Joss. ex Watling) Redhead, Vilgalys & Moncalvo

Pernambuco, on cattle and goat dung (Melo & al. 2016).

Coprinopsis stercorea (Fr.) Redhead, Vilgalys & Moncalvo

Pernambuco, on cattle dung (Melo & al. 2016).

Goiás, on pig dung (Calaça & Xavier-Santos 2017).

Coprinopsis vermiculifer (Joss. ex Dennis) Redhead, Vilgalys & Moncalvo

Pernambuco, on horse dung (Melo & al. 2016).

Panaeolus antillarum (Fr.) Dennis

Pernambuco, on horse, cattle and goat dung (Melo & al. 2016).

Paraná, on cattle dung (Silva-Filho & al. 2019).

Panaeolus cyanescens Sacc.

Paraná, as *Copelandia cyanescens* (Berk. & Broome) Singer, on cattle dung (Silva-Filho & al. 2018).

Panaeolus papilionaceus (Bull.) Qué.

= *Panaeolus papilionaceus* var. *parvisporus* Ew. Gerhardt

Paraná, on cattle dung (Silva-Filho & al. 2019).

Parasola misera (P. Karst.) Redhead, Vilgalys & Hopple

Goiás, on horse and cattle dung (Calaça & Xavier-Santos 2017).

Incertae sedis in Agaricales

Cyathus stercoreus (Schwein.) De Toni

Rio Grande do Sul, on undefined dung type (Trierveiler-Pereira & al. 2018).

Phallales E. Fisch.

Phallaceae Corda

Lysurus arachnoideus (E. Fisch.) Trierv.-Per. & K. Hosaka

*Amazonas, on undefined dung type (Cabral & al. 2015).

Other kingdoms

Protozoa R. Owen

Amoebozoa Lühe

Myxomycota Traub

Liceales E. Jahn

Liceaceae Chevall.

Licea tenera E. Jahn

Rio Grande do Sul, on horse, sheep and cattle dung (Lima & Cavalcanti 2017).

Physarales T. Macbr.

Physaraceae Chevall.

Physarum cf. notabile T. Macbr.

Rio Grande do Sul, on undefined dung type (Lima & Cavalcanti 2017).

Trichiales T. Macbr.

Trichiaceae Chevall.

Arcyria cinerea (Bull.) Pers.

*Piauí, on rock-cavy (*Kerodon rupestris* Wied-Neuwied) dung (Parente & Cavalcanti 2017).

Bacteria Woese, Kandler & Wheelis

Actinobacteria Stackebrandt, Rainey, & Ward-Raine

Incertae sedis in Actinomycetales Buchanan

Palaeostromatus diairetus Dentzien-Dias, Poinar-Jr. & Francischini

Rio Grande do Sul, inside a fossilized fecal matrix (coprolite) (Dentzien-Dias & al. 2016).

Proteobacteria Garrity, Bell & Lilburn**Incertae sedis in Myxococcales** Tchan, Pochon & Prévot***Chondromyces crocatus*** Berk. & M.A. Curtis

Goiás, on cattle, pig and guinea fowl (*Numida meleagris* L.) dung (Calaça & Xavier-Santos 2017).

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