Scientific Research Publishing

Advances in Microbiology, 2018, 8, 324-353
http://www.scirp.org/journal/aim
ISSN Online: 2165-3410
ISSN Print: 2165-3402

# Indoor Air Mycological Survey and Occupational Exposure in Libraries in Mato Grosso-Central Region—Brazil

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**How to cite this paper:** Leite-Jr., D.P., Pereira, R.S., Almeida, W.S., Simões, S.A.A., Yamamoto, A.C.A., Souza, J.V.R., Martins, E.R., Leal-Santos, F.A. and Hahn, R.C. (2018) Indoor Air Mycological Survey and Occupational Exposure in Libraries in Mato Grosso-Central Region—Brazil. *Advances in Microbiology*, **8**, 324-353.
https://doi.org/10.4236/aim.2018.84022

**Received:** March 7, 2018
**Accepted:** April 23, 2018
**Published:** April 30, 2018



## Abstract

**Background:** Indoor air quality in environments where there is great circulation of people, posing risks to the health of its occupants, including allergic problems, infections and contaminations, can be aided by climatic factors, chemicals and biological agents housed in these environments, influencing the location and providing favorable conditions for the degradation of bibliographic collections. The present study investigated the presence of fungi in indoor environments in seven public and private libraries in the central region of Brazil, Mato Grosso, and verified the impact on occupational health. **Results:** A total of 26,194 fungal specimens were isolated from 342 dust samples collected using three techniques: Andersen's sampler (12.3%), exposure plate dish (25.1%) and sterile swab (62.6%). A total of 184 fungal species were identified: 156 (84.8%) mycelial fungi and 28 (15.2%) yeast fungi, belonging 54 fungal genera, 43 (79.6%) mycelial fungi and 11 (20.4%) yeast fungi. The genus *Aspergillus* (40.6%) was one of the main fungi present in indoor air. *Aspergillus niger* (12.3%) was identified as the most prevalent species in literary environments, followed by *Cryptococcus* spp. (7.1%) and *Cladosporium cladosporioides* (7.0%). In relation to seasonal distribution, there was a greater fungal isolation in the dry season (54%); followed by the rainy season (46%). **Conclusion:** These results suggest the substrates researched in the evaluated

environments presented in the form of documents, books and papers associated with dust and air humidity become suitable for microbiological proliferation. These findings highlight the importance of minimizing the risk of exposure to fungal agents, identified in pathogenic and toxigenic microenvironments in library collections.

## Keywords

Biological Hazards, Library Collections, Anemophilous Fungi, Indoor Air Quality

## 1. Introduction

Recent studies suggested that there may be around 1.5 to 5.1 million extant fungal species and about 1200 new species are being described in each year [1]. However, the authors caution that these numbers refer to inferences and estimates for each country.

The great biological diversity of Brazilian regions makes Brazil a country with high biodiversity, coupled with the endemism of some species. This richness is distributed in the national territory in six continental biomes: Atlantic Rainforest, Pantanal, Amazon, Caatinga, Cerrado and Pampas, which are characterized by certain uniformity in their environmental regions such as climate, temperature, soil and characteristic physiognomy [2].

Fungal microorganisms can affect all types of archives, regardless of their constitution. Their propagules are dispersed in the environment and over the surface of objects in most places. In this way, careful attention must be paid to fungal contamination in books, periodicals and documents, since this exposes such archives to the risk of damage [3]. Contamination can also provoke allergic processes, with aggravated clinical symptoms occurring among those that handle these archives and become exposed to the action of these fungi [4].

Diseases related to the quality of indoor air have been classified by the World Health Organization [5] as Sick Building Syndrome (SBS). Currently symptoms related to SBS are described by those who remain in enclosed spaces 90% of the time. Diagnosing SBS is eminently epidemiological [4] [6].

More complex health effects occur when characterizing SBS (Sick Building Syndrome) or BRI (Building Related Illness). The symptoms can include irritation of mucous membranes, skin and eyes, fatigue, headache, malaise, lethargy, difficulty concentrating, sensitivity to odors and flu-like symptoms, but no causative agent is usually identified. In almost all cases, BRI is an advanced stage of SBS [6].

The objective of this work was to evaluate the fungal biodiversity in different environments of seven libraries of Mato Grosso-Central West region of Brazil, and to establish a possible correlation with the occupational health of the visitors.

## 2. Materials and Methods

### 2.1. Climatic Characterization

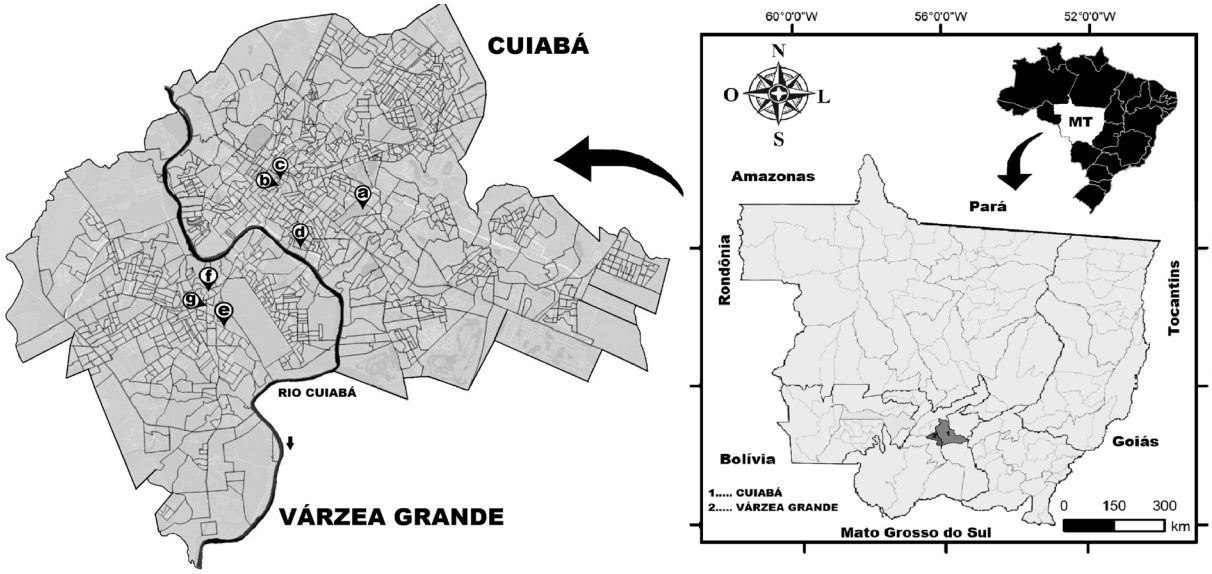
The climate is characteristic of the semiarid region-Savana Tropical (AW), with a mean annual rainfall of 1469.4 mm and average annual temperature of 24˚C to 26˚C. The municipality is surrounded by three large ecosystems: the Amazon, the cerrado and the pantanal. The city of Cuiabá is the capital of the State of Mato Grosso, its location presents the coordinates 15˚35' - 56˚07' and altitude of 151 meters above sea level [7] (**Figure 1**).

### 2.2. Description of Sample Collection

Sample collections were divided into two seasonal periods: two conducted in the rainy season in January and March (2014), and another in the dry season in July to September (2014), totaling 342 samples using three methodologies. Samples were collected on two random days within each climatic period, ranging from 15 to 20 days between the first collection and the second collection for each climatic period (two in the dry season and two in the rainy season).

The temperature (T) and relative humidity (RH) were evaluated inside these repositories at each sampling point at the time the microbiological collection was being carried out using two digital thermocouples with reading capacity −10 + 60˚C (Model 7429.02.0.00 Brand Incoterm).

One-third the samples collected were achieved by sedimentation in petri dishes containing Sabouraud agar (Difco™BD™, France) added with cloranphenicol (100 mg/mL) [8] and 114 samples were collected using the Andersen's




The geographical position of the sample collection points were located: Library A (15°36'37.00"S-56°03'46.63"W); Library B (15°35'53.18"S-56°05'46.43"W); Library C (15°35'53.00"S-56°05'47.00"W); Library D (15°35'53.18"S-56°05'46.43"W); Library E (15°39'18.01"S-56°07'18.02"W); Library F (15°38'29.04"S-56°06'11.08"W); Library G (15°39'08.04"S-56°07'53.08"W).

**Figure 1.** Map of the State of Mato Grosso, Brazil (right). Urban area of the cities of Cuiabá and Várzea Grande (left) where dust samples were collected from the seven libraries in 2014 and their location points (Libraries a, b, c, d, e, f, g).

Sampler technique and another 114 samples by rubbing a sterile swab on the surfaces of books, periodicals and other documents in libraries.

The petri dishes were opened inside the selected locations, mainly placed on surfaces parallel to the floor, such as countertops, cabinets and shelves, for about 30 min, at a height of 1.20 cm to 1.50 cm, as described by Gambale [9] and Reis-Menezes [10]. As the exposure time elapsed, the other collections by the Swab method on books and the sampler method of Andersen were applied. The places chosen for exposure were standardized so that each of the petri dishes ware also exposed equally during the four collections.

For collection, the swab was moistened in 20% saline with chloramphenicol. The collection area was delimited using a sterile template, 10 cm × 10 cm (100 $cm^2$). The swabs were pressure-rubbed at an angle of 30˚ with the test surface, twenty times zig-zag shape, in the diagonal directions, in the area of surface collection, in the space delimited by the mold. Other sections of the books and documents that are arranged on the shelves were also rubbed for substrate collection [11] [12].

The dust samples were packed in sterilized polyethylene boxes and bags and transported to the Laboratory of Investigation in Micology (UFMT). In the laboratory, each swab was seeded on a 150 × 15 mm petri dish containing Sabouraud agar with chloramphenicol (100 mg/mL), which was then incubated in a BOD incubator at 27˚C for 5 - 7 days, until colony forming units (CFUs) were observed [8].

## 2.3. Fungal Isolation and Species Identification

Observation of the macro morphological characteristics of the colonies was achieved using specific media to observe and identify the characteristic macro morphology of the colonies: CYA 25 (Czapeck Agar Yeast Extract 25), CYA 37 (Czapeck Yeast Extract Agar at 37), CY 20S (Czapeck Yeast Extract Agar with 20% sucrose) and MEA (Malt Extract Agar); as previously established [13] [14] [15] were carnation leaf agar (CLA), banana leaf agar (BLA) and potato dextrose agar (PDA) [16].

Riddel's technique [8] was used to assess the microscopic structures of yeast and filamentous fungi on slides stained with lactophenol cotton blue. Colonies with yeast-like forms were purified and seeded on CHROMagar™Candida, according to the characteristics of the colonies using specific morphophysiological evidence. Biochemical tests were performed, urease technique, CGB (L-canavanine-glycine-bromothymol blue), production of phenol-oxidase in ágar seeds niger (*Guizotia abyssinica*) and auxanogram, which included the assimilation of carbon sources and nitrogen source [17]. These were used as complementary tests for differentiation, identification and confirmation at the species level.

Identification was carried out by specific mycological methods for each group of isolated fungi, as well as with specific bibliographic [8] [14] [15] [17]-[23].

### 2.4. Data Analysis

Were analysed the data using Sörensen's similarity index ($S_S$), Fisher's (α), Shannon-Wiener's diversity index (H'), Simpson's diversity index (1/D), Margalef's richness index ($I_{Mg}$), Menhinick's richness index (1/d), diversity indices were calculated using software Microsoft Excel™ 2010.

## 3. Results

### 3.1. Study Areas Characterization

#### 3.1.1. Diversity Samples

A total 26,194 colonies were isolated and 54 taxa and 183 species of fungal microorganisms were identified, of these species, 156 (85.2%) characterized as mycelial fungi and 27 (14.7%) as yeast fungi. The fungal genera isolated were mycelial fungi (43; 79.6%) and yeasts (11; 20.4%). A total of 342 samples were collected in the following sections: periodicals, study areas, rare books, archive storage and display areas of seven libraries, four located in the city of Cuiabá and three located in the city of Várzea Grande, Mato Grosso, Brazil (**Figure 1**).

Differences were observed among the three collection techniques applied in the acquisition of fungal propagules. The swab technique proved to be more efficient in capturing the samples 16,387 (62.6%), followed by the sedimentation technique in petri dishes 6578 (25.1%) and the Andersen's sampler technique 3229 (12.3%) (**Table 1**).

The incidence of fungal propagules was also verified for rainy season (January to March/2014) and dry season (July to September/2014) collections in the seven libraries a, b, c, d, e, f, g evaluated (**Figure 1**). The choice of sampling sites was randomized [24], have been observed 26,194 fungal CFU's grown in the petri dishes exposed (gravitational method), collected from Andersen's sampler and seeded by swabs (**Figure 2**). The number of Colony Forming Units (CFU) for the dry season 13,991 (54.3%) presented a higher index isolating compared to the rainy season 12,062 (46.6%) (**Table 1**).

The number of Colony Forming Units (CFU) for the dry season 13,991 (54.3%) presented a higher index isolating compared to the rainy season 12,062 (46.6%). Despite this high isolation rate of colonies in the dry period, this period presented a lower number of isolates of fungic genera (35 taxa) than the rainy season (45 taxa).

Fifty-four taxa were identified from samples obtained in the four collections conducted, two during the rainy season and the two during the dry season. Twenty-seven genera (50%) were identified from samples collected in both seasons: *Acremonium*, *Alternaria*, *Aspergillus*, *Aureobasidium*, *Bipolaris*, *Candida*, *Chrysonilia*, *Chrysosporium*, Cladophialophora, *Cladosporium*, *Cryptococcus*, *Curvularia*, *Fonsecaea*, *Fusarium*, *Mucor*, *Mycelia sterilia*, *Neocytalidium*, *Paecilomyces*, *Penicillium*, *Pestalotiopsis*, *Phaeacremonium*, *Rhizopus*, *Rhodotorula*, *Saccharomyces*, *Sporobolomyces*, *Talaromyces*, *Trichoderma.*

**Table 1.** Frequency of colony-forming units (CFU) of filamentous fungi and yeasts isolated from dust seven libraries, applying three collection methodology: Andersen' sampler (AS); exposure in petri dish (PD) and sterile swab (SW), during the rainy season and dry season in 2014, in the municipalities of Cuiabá and Várzea Grande—MT, Brazil.

| ENVIROMENTAL SPECIMENS | | | SAMPLES | | | | |
|---|---|---|---|---|---|---|---|
| | | | AS | PD | SW | TOTAL | |
| SEQ. | Filo/Families | Isolated species | N | N | N | N | % |
| | | ASCOMYCOTA | | | | | |
| 01 | Aspergillaceae | *Aspergillus aculeatus* | 40 | 143 | 48 | 231 | 0.9 |
| 02 | Aspergillaceae | *Aspergillus amstelodami* | 0 | 11 | 4 | 15 | 0.1 |
| 03 | Aspergillaceae | *Aspergillus awamorii* | 118 | 280 | 679 | 1077 | 4.1 |
| 04 | Aspergillaceae | *Aspergillus candidus* | 5 | 26 | 5 | 36 | 0.1 |
| 05 | Aspergillaceae | *Aspergillus carbonarius* | 98 | 143 | 189 | 430 | 1.6 |
| 06 | Aspergillaceae | *Aspergillus carneus* | 0 | 12 | 3 | 15 | 0.1 |
| 07 | Aspergillaceae | *Aspergillus chevalieri* | 0 | 12 | 2 | 14 | 0.1 |
| 08 | Aspergillaceae | *Aspergillus clavatus* | 59 | 21 | 194 | 274 | 1.0 |
| 09 | Aspergillaceae | *Aspergillus clavatus-nanicus* | 0 | 26 | 2 | 28 | 0.1 |
| 10 | Aspergillaceae | *Aspergillus conicus* | 0 | 0 | 8 | 8 | 0.0 |
| 11 | Aspergillaceae | *Aspergillus fischerianus* | 6 | 27 | 3 | 36 | 0.1 |
| 12 | Aspergillaceae | *Aspergillus flavipes* | 0 | 24 | 3 | 27 | 0.1 |
| 13 | Aspergillaceae | *Aspergillus flavus* | 285 | 532 | 801 | 1618 | 6.2 |
| 14 | Aspergillaceae | *Aspergillus flavus-furcatis* | 0 | 10 | 0 | 10 | 0.0 |
| 15 | Aspergillaceae | *Aspergillus fumigatus* | 39 | 50 | 93 | 182 | 0.7 |
| 16 | Aspergillaceae | *Aspergillus giganteus* | 12 | 10 | 0 | 22 | 0.1 |
| 17 | Aspergillaceae | *Aspergillus glaucus* | 0 | 35 | 0 | 35 | 0.1 |
| 18 | Aspergillaceae | *Aspergillus japonicus* | 114 | 207 | 308 | 629 | 2.4 |
| 19 | Aspergillaceae | *Aspergillus melleus* | 0 | 2 | 7 | 9 | 0.0 |
| 20 | Aspergillaceae | *Aspergillus minesclerotigenes* | 0 | 0 | 8 | 8 | 0.0 |
| 21 | Aspergillaceae | *Aspergillus nidulans* | 71 | 74 | 661 | 806 | 3.1 |
| 22 | Aspergillaceae | *Aspergillus niger* | 464 | 783 | 1972 | 3219 | 12.3 |
| 23 | Aspergillaceae | *Aspergillus nomius* | 0 | 2 | 0 | 2 | 0.0 |
| 24 | Aspergillaceae | *Aspergillus ochraceus* | 17 | 15 | 123 | 155 | 0.6 |
| 25 | Aspergillaceae | *Aspergillus ornatulus* | 3 | 0 | 0 | 3 | 0.0 |
| 26 | Aspergillaceae | *Aspergillus oryzae* | 19 | 24 | 144 | 187 | 0.7 |
| 27 | Aspergillaceae | *Aspergillus parasiticus* | 90 | 110 | 141 | 341 | 1.3 |
| 28 | Aspergillaceae | *Aspergillus penicillioides* | 0 | 3 | 11 | 14 | 0.1 |
| 29 | Aspergillaceae | *Aspergillus quadrillineatus* | 0 | 0 | 25 | 25 | 0.1 |
| 30 | Aspergillaceae | *Aspergillus reptans* | 2 | 0 | 9 | 11 | 0.0 |
| 31 | Aspergillaceae | *Aspergillus rubrum* | 0 | 17 | 0 | 17 | 0.1 |

**Continued**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 32 | Aspergillaceae | *Aspergillus sclerotiioniger* | 4 | 0 | 0 | 4 | 0.0 |
| 33 | Aspergillaceae | *Aspergillus sclerotiorum* | 10 | 8 | 3 | 21 | 0.1 |
| 34 | Aspergillaceae | *Aspergillus sojae* | 5 | 10 | 8 | 23 | 0.1 |
| 35 | Aspergillaceae | *Aspergillus sulphureus* | 0 | 0 | 3 | 3 | 0.0 |
| 36 | Aspergillaceae | *Aspergillus sydowii* | 9 | 6 | 8 | 23 | 0.1 |
| 37 | Aspergillaceae | *Aspergillus tamarii* | 197 | 252 | 232 | 681 | 2.6 |
| 38 | Aspergillaceae | *Aspergillus terreus* | 16 | 49 | 64 | 129 | 0.5 |
| 39 | Aspergillaceae | *Aspergillus unguis* | 17 | 31 | 99 | 147 | 0.6 |
| 40 | Aspergillaceae | *Aspergillus ustus* | 0 | 10 | 0 | 10 | 0.0 |
| 41 | Aspergillaceae | *Aspergillus versicolor* | 37 | 16 | 49 | 102 | 0.4 |
| 42 | Aspergillaceae | *Aspergillus violaceofuscus* | 0 | 8 | 12 | 20 | 0.1 |
| 43 | Aspergillaceae | *Monascus ruber* | 0 | 9 | 0 | 9 | 0.0 |
| 44 | Aspergillaceae | *Penicillium chrysogenum* | 6 | 12 | 21 | 39 | 0.1 |
| 45 | Aspergillaceae | *Penicillium citreonigrum* | 7 | 3 | 12 | 22 | 0.1 |
| 46 | Aspergillaceae | *Penicillium citrinum* | 174 | 145 | 331 | 650 | 2.5 |
| 47 | Aspergillaceae | *Penicillium corylophilum* | 0 | 1 | 6 | 7 | 0.0 |
| 48 | Aspergillaceae | *Penicillium digitatum* | 4 | 0 | 4 | 8 | 0.0 |
| 49 | Aspergillaceae | *Penicillium expansum* | 17 | 13 | 0 | 30 | 0.1 |
| 50 | Aspergillaceae | *Penicillium glabrum* | 63 | 142 | 87 | 292 | 1.1 |
| 51 | Aspergillaceae | *Penicillium implicatum* | 2 | 2 | 0 | 4 | 0.0 |
| 52 | Aspergillaceae | *Penicillium italicum* | 0 | 8 | 10 | 18 | 0.1 |
| 53 | Aspergillaceae | *Penicillium oxalicum* | 0 | 3 | 28 | 31 | 0.1 |
| 54 | Aspergillaceae | *Penicillium restrictum* | 0 | 25 | 11 | 36 | 0.1 |
| 55 | Aspergillaceae | *Penicillium sclerotiorum* | 0 | 2 | 0 | 2 | 0.0 |
| 56 | Aspergillaceae | *Penicillium simplicissimum* | 0 | 2 | 37 | 39 | 0.1 |
| 57 | Aspergillaceae | *Penicillium spinulosum* | 7 | 12 | 0 | 19 | 0.1 |
| 58 | Aspergillaceae | *Penicillium variabilis* | 0 | 0 | 63 | 63 | 0.2 |
| 59 | Botryosphaeriaceae | *Macrophomina phaseolina* | 7 | 0 | 0 | 7 | 0.0 |
| 60 | Chaetomiaceae | *Chaetomium globosum* | 5 | 0 | 0 | 5 | 0.0 |
| 61 | Clavicipitaceae | *Mariannaea elegans* | 0 | 3 | 0 | 3 | 0.0 |
| 62 | Clavicipitaceae | *Tritirachium oryzae* | 5 | 6 | 0 | 11 | 0.0 |
| 63 | Davidiellaeae | *Cladosporium cladosporioides* | 194 | 357 | 1274 | 1825 | 7.0 |
| 64 | Davidiellaeae | *Cladosporium colocasiae* | 0 | 0 | 5 | 5 | 0.0 |
| 65 | Davidiellaeae | *Cladosporium delicatulum* | 0 | 0 | 31 | 31 | 0.1 |
| 66 | Davidiellaeae | *Cladosporium elatum* | 0 | 13 | 0 | 13 | 0.0 |
| 67 | Davidiellaeae | *Cladosporium herbarum* | 48 | 8 | 0 | 56 | 0.2 |
| 68 | Davidiellaeae | *Cladosporium macrocarpum* | 2 | 0 | 0 | 2 | 0.0 |

**Continued**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 69 | Davidiellaeae | *Cladosporium sphaerospermum* | 5 | 148 | 126 | 279 | 1.1 |
| 70 | Davidiellaeae | *Cladosporium tenuissimum* | 0 | 33 | 0 | 33 | 0.1 |
| 71 | Dothioraceae | *Aureobasidium melanogenum* | 6 | 55 | 54 | 115 | 0.4 |
| 72 | Dothioraceae | *Aureobasidium pullulans* | 25 | 78 | 71 | 174 | 0.7 |
| 73 | Dothioraceae | *Hormonema dematioides* | 0 | 0 | 5 | 5 | 0.0 |
| 74 | Endomycetaceae | *Geotrichum candidum* | 0 | 0 | 2 | 2 | 0.0 |
| 75 | Endomycetaceae | *Geotrichum clavatum* | 0 | 0 | 5 | 5 | 0.0 |
| 76 | Herpotrichiellaceae | *Cladophialophora bantiana* | 25 | 89 | 0 | 114 | 0.4 |
| 77 | Herpotrichiellaceae | *Cladophialophora carrionii* | 43 | 15 | 12 | 70 | 0.3 |
| 78 | Herpotrichiellaceae | *Fonsecaea compacta* | 0 | 0 | 12 | 12 | 0.0 |
| 79 | Herpotrichiellaceae | *Fonsecaea pedrosoi* | 0 | 0 | 3 | 3 | 0.0 |
| 80 | Herpotrichiellaceae | *Rinocladiella aquaspersa* | 12 | 0 | 0 | 12 | 0.0 |
| 81 | Microascaceae | *Graphium putredinis* | 0 | 2 | 3 | 5 | 0.0 |
| 82 | Microascaceae | *Scopulariopsis brevicaulis* | 0 | 0 | 2 | 2 | 0.0 |
| 83 | Nectriaceae | *Fusarium avenaceum* | 1 | 0 | 8 | 9 | 0.0 |
| 84 | Nectriaceae | *Fusarium chlamydosporum* | 5 | 0 | 0 | 5 | 0.0 |
| 85 | Nectriaceae | *Fusarium dimerum* | 0 | 5 | 0 | 5 | 0.0 |
| 86 | Nectriaceae | *Fusarium graminearum* | 9 | 97 | 190 | 296 | 1.1 |
| 87 | Nectriaceae | *Fusarium oxysporum* | 2 | 160 | 433 | 595 | 2.3 |
| 88 | Nectriaceae | *Fusarium proliferatum* | 0 | 67 | 23 | 90 | 0.3 |
| 89 | Nectriaceae | *Fusarium roseum* | 0 | 1 | 0 | 1 | 0.0 |
| 90 | Nectriaceae | *Fusarium solani* | 10 | 92 | 8 | 110 | 0.4 |
| 91 | Nectriaceae | *Fusarium sporotrichoides* | 6 | 0 | 8 | 14 | 0.1 |
| 92 | Nectriaceae | *Fusarium verticillioides* | 37 | 93 | 115 | 245 | 0.9 |
| 93 | Saccharomycetaceae | *Bispora bertulina* | 0 | 10 | 0 | 10 | 0.0 |
| 94 | Saccharomycetaceae | *Candida albicans* | 3 | 2 | 17 | 22 | 0.1 |
| 95 | Saccharomycetaceae | *Candida glabrata* | 9 | 0 | 10 | 19 | 0.1 |
| 96 | Saccharomycetaceae | *Candida intermedia* | 3 | 3 | 0 | 6 | 0.0 |
| 97 | Saccharomycetaceae | *Candida kefyr* | 0 | 15 | 14 | 29 | 0.1 |
| 98 | Saccharomycetaceae | *Candida krusei* | 2 | 5 | 21 | 28 | 0.1 |
| 99 | Saccharomycetaceae | *Candida parapsilosis* | 0 | 11 | 29 | 40 | 0.2 |
| 100 | Saccharomycetaceae | *Candida tropicalis* | 0 | 2 | 43 | 45 | 0.2 |
| 101 | Saccharomycetaceae | *Candida viswanathii* | 0 | 0 | 3 | 3 | 0.0 |
| 102 | Saccharomycetaceae | *Candida zeylanoides* | 0 | 3 | 0 | 3 | 0.0 |
| 103 | Saccharomycetaceae | *Hanseniaspora apiculata* | 0 | 6 | 0 | 6 | 0.0 |
| 104 | Saccharomycetaceae | *Hansenula anomala* | 0 | 9 | 0 | 9 | 0.0 |
| 105 | Saccharomycetaceae | *Saccharomyces cerevisae* | 1 | 23 | 58 | 82 | 0.3 |

**Continued**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 106 | Saccharomycetaceae | *Saccharomyces ellipsoideus* | 3 | 2 | 0 | 5 | 0.0 |
| 107 | Trichocomaceae | *Talaromyces purpurogenus* | 25 | 28 | 2 | 55 | 0.2 |
| 108 | Trichocomaceae | *Talaromyces rugulosus* | 2 | 0 | 11 | 13 | 0.0 |
| 109 | Trichocomaceae | *Talaromyces verruculosus* | 6 | 0 | 0 | 6 | 0.0 |
| | | **BASIDIOMYCOTA** | | | | | |
| 110 | Cryptococaceae | *Cryptococcus* spp. | 53 | 272 | 1540 | 1865 | 7.1 |
| 111 | Cryptococaceae | *Rhodotorula aurantiaca* | 0 | 0 | 63 | 63 | 0.2 |
| 112 | Cryptococaceae | *Rhodotorula glutinis* | 29 | 24 | 985 | 1038 | 4.0 |
| 113 | Cryptococaceae | *Rhodotorula minuta* | 17 | 16 | 220 | 253 | 1.0 |
| 114 | Cryptococaceae | *Rhodotorula mucilaginosa* | 6 | 75 | 1193 | 1274 | 4.9 |
| 115 | Sporodiobolaceae | *Sporobolomyces roseus* | 4 | 0 | 0 | 4 | 0.0 |
| 116 | Sporodiobolaceae | *Sporobolomyces salmonicolor* | 0 | 3 | 0 | 3 | 0.0 |
| 117 | Trichosporonaceae | *Trichosporon* spp. | 4 | 0 | 8 | 12 | 0.0 |
| | | **DEUTEROMYCOTA** | | | | | |
| 118 | Amphisphariaceae | *Pestalotiopsis funerea* | 0 | 0 | 0 | 0 | 0.0 |
| 119 | Amphisphariaceae | *Pestalotiopsis microspora* | 2 | 14 | 5 | 21 | 0.1 |
| 120 | Botryosphaeriaceae | *Neoscytalidium dimidiatum* | 0 | 12 | 53 | 65 | 0.2 |
| 121 | Botryosphaeriaceae | *Neoscytalidium hialinum* | 17 | 84 | 23 | 124 | 0.5 |
| 122 | Botryosphaeriaceae | *Phaeoacremonium parasiticum* | 2 | 19 | 60 | 81 | 0.3 |
| 123 | Clavicipitaceae | *Paecilomyces carneus* | 9 | 8 | 64 | 81 | 0.3 |
| 124 | Clavicipitaceae | *Paecilomyces farinosus* | 0 | 0 | 72 | 72 | 0.3 |
| 125 | Clavicipitaceae | *Paecilomyces fumosoroseus* | 0 | 0 | 8 | 8 | 0.0 |
| 126 | Clavicipitaceae | *Paecilomyces lilacinus* | 32 | 14 | 401 | 447 | 1.7 |
| 127 | Clavicipitaceae | *Paecilomyces penicillatus* | 0 | 2 | 0 | 2 | 0.0 |
| 128 | Clavicipitaceae | *Paecilomyces variotii* | 38 | 157 | 34 | 229 | 0.9 |
| 129 | Clavicipitaceae | *Paecilomyces viride* | 40 | 29 | 21 | 90 | 0.3 |
| 130 | Herpotrichiellaceae | *Phialophora richardsiae* | 0 | 13 | 0 | 13 | 0.0 |
| 131 | Hypocreaceae | *Acremonium chrysogenum* | 0 | 8 | 1 | 9 | 0.0 |
| 132 | Hypocreaceae | *Acremonium falciforme* | 0 | 22 | 14 | 36 | 0.1 |
| 133 | Hypocreaceae | *Acremonium kiliensi* | 0 | 15 | 103 | 118 | 0.5 |
| 134 | Hypocreaceae | *Alternaria alternata* | 52 | 110 | 323 | 485 | 1.9 |
| 135 | Hypocreaceae | *Alternaria chlamydospora* | 0 | 2 | 0 | 2 | 0.0 |
| 136 | Hypocreaceae | *Alternaria citri* | 0 | 2 | 26 | 28 | 0.1 |
| 137 | Hypocreaceae | *Alternaria geophila* | 0 | 6 | 41 | 47 | 0.2 |

**Continued**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 138 | Hypocreaceae | *Alternaria infectoria* | 12 | 0 | 239 | 251 | 1.0 |
| 139 | Hypocreaceae | *Alternaria longissima* | 0 | 7 | 0 | 7 | 0.0 |
| 140 | Hypocreaceae | *Alternaria tenuissima* | 0 | 12 | 0 | 12 | 0.0 |
| 141 | Hypocreaceae | *Trichoderma longibrachiatum* | 0 | 21 | 0 | 21 | 0.1 |
| 142 | Hypocreaceae | *Trichoderma roseum* | 0 | 3 | 0 | 3 | 0.0 |
| 143 | Hypocreaceae | *Trichoderma viride* | 45 | 123 | 344 | 512 | 2.0 |
| 144 | Microascaceae | *Scedosporium apiospermum* | 11 | 2 | 0 | 13 | 0.0 |
| 145 | Microascaceae | *Scedosporium prolificans* | 0 | 6 | 0 | 6 | 0.0 |
| 146 | Nectriaceae | *Cylindrocarpon destructans* | 0 | 0 | 6 | 6 | 0.0 |
| 147 | Onygenaceae | *Chrysosporium fastidium* | 18 | 6 | 0 | 24 | 0.1 |
| 148 | Onygenaceae | *Chrysosporium keratinophilum* | 0 | 11 | 0 | 11 | 0.0 |
| 149 | Onygenaceae | *Chrysosporium zonatum* | 0 | 0 | 0 | 0 | 0.0 |
| 150 | Pleosporaceae | *Bipolaris australiensis* | 2 | 0 | 81 | 83 | 0.3 |
| 151 | Pleosporaceae | *Bipolaris hawaiiensis* | 5 | 0 | 0 | 5 | 0.0 |
| 152 | Pleosporaceae | *Bipolaris spicifera* | 6 | 22 | 24 | 52 | 0.2 |
| 153 | Pleosporaceae | *Epicoccum nigrum* | 0 | 12 | 0 | 12 | 0.0 |
| 154 | Pleosporaceae | *Epicoccum purpurascens* | 24 | 0 | 0 | 24 | 0.1 |
| 155 | Pleosporaceae | *Exserohilum rostratum* | 6 | 3 | 0 | 9 | 0.0 |
| 156 | Pleosporaceae | *Ulocladium alternariae* | 0 | 1 | 0 | 1 | 0.0 |
| 157 | Pleosporaceae | *Ulocladium botrytis* | 0 | 19 | 10 | 29 | 0.1 |
| 158 | Pleosporaceae | *Stemphylium botryosum* | 5 | 0 | 0 | 5 | 0.0 |
| 159 | Pleosporales | *Curvularia aerea* | 6 | 9 | 39 | 54 | 0.2 |
| 160 | Pleosporales | *Curvularia brachyspora* | 7 | 0 | 0 | 7 | 0.0 |
| 161 | Pleosporales | *Curvularia clavata* | 3 | 7 | 0 | 10 | 0.0 |
| 162 | Pleosporales | *Curvularia eragostridis* | 0 | 0 | 12 | 12 | 0.0 |
| 163 | Pleosporales | *Curvularia lunata* | 29 | 137 | 619 | 785 | 3.0 |
| 164 | Pleosporales | *Curvularia ovoide* | 0 | 2 | 3 | 5 | 0.0 |
| 165 | Pleosporales | *Curvularia pallescens* | 10 | 0 | 0 | 10 | 0.0 |
| 166 | Sordariaceae | *Chrysonilia sitophila* | 59 | 151 | 27 | 237 | 0.9 |
| 167 | Stachybotryaceae | *Stacybotrys equinata* | 5 | 0 | 0 | 5 | 0.0 |
| 168 | Trichosphaeriaceae | *Nigrospora sphaerica* | 0 | 0 | 5 | 5 | 0.0 |
| | | **ZIGOMYCOTA** | | | | | |
| 169 | Cunninghamellaceae | *Cunninghamela bertholetiae* | 3 | 12 | 31 | 46 | 0.2 |
| 170 | Mucoraceae | *Absidia corymbifera* | 0 | 3 | 0 | 3 | 0.0 |
| 171 | Mucoraceae | *Circinella muscae* | 0 | 0 | 2 | 2 | 0.0 |
| 172 | Mucoraceae | *Mucor circinelloides* | 2 | 39 | 38 | 79 | 0.3 |
| 173 | Mucoraceae | *Mucor hiemalis* | 8 | 14 | 109 | 131 | 0.5 |

**Continued**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 174 | Mucoraceae | *Mucor mucedo* | 0 | 0 | 17 | 17 | 0.1 |
| 175 | Mucoraceae | *Mucor racemosus* | 0 | 0 | 3 | 3 | 0.0 |
| 176 | Mucoraceae | *Rhizopus chlamydosporus* | 1 | 0 | 0 | 1 | 0.0 |
| 177 | Mucoraceae | *Rhizopus microsporus* | 0 | 0 | 7 | 7 | 0.0 |
| 178 | Mucoraceae | *Rhizopus rhizopodiformis* | 0 | 3 | 0 | 3 | 0.0 |
| 179 | Mucoraceae | *Rhizopus oryzae* | 35 | 55 | 66 | 156 | 0.6 |
| 180 | Mucoraceae | *Rhizopus schipperae* | 4 | 0 | 0 | 4 | 0.0 |
| 181 | Mucoraceae | *Rhizopus stolonifer* | 55 | 77 | 224 | 356 | 1.4 |
| 182 | Syncephalastraceae | *Scyncephalastrum racemosum* | 0 | 0 | 54 | 54 | 0.2 |
| 183 | **AGNOMICETES** | *Mycelia sterilia* | 45 | 105 | 40 | 190 | 0.7 |
| | | **TOTAL** | **3229** | **6578** | **16387** | **26194** | **100** |

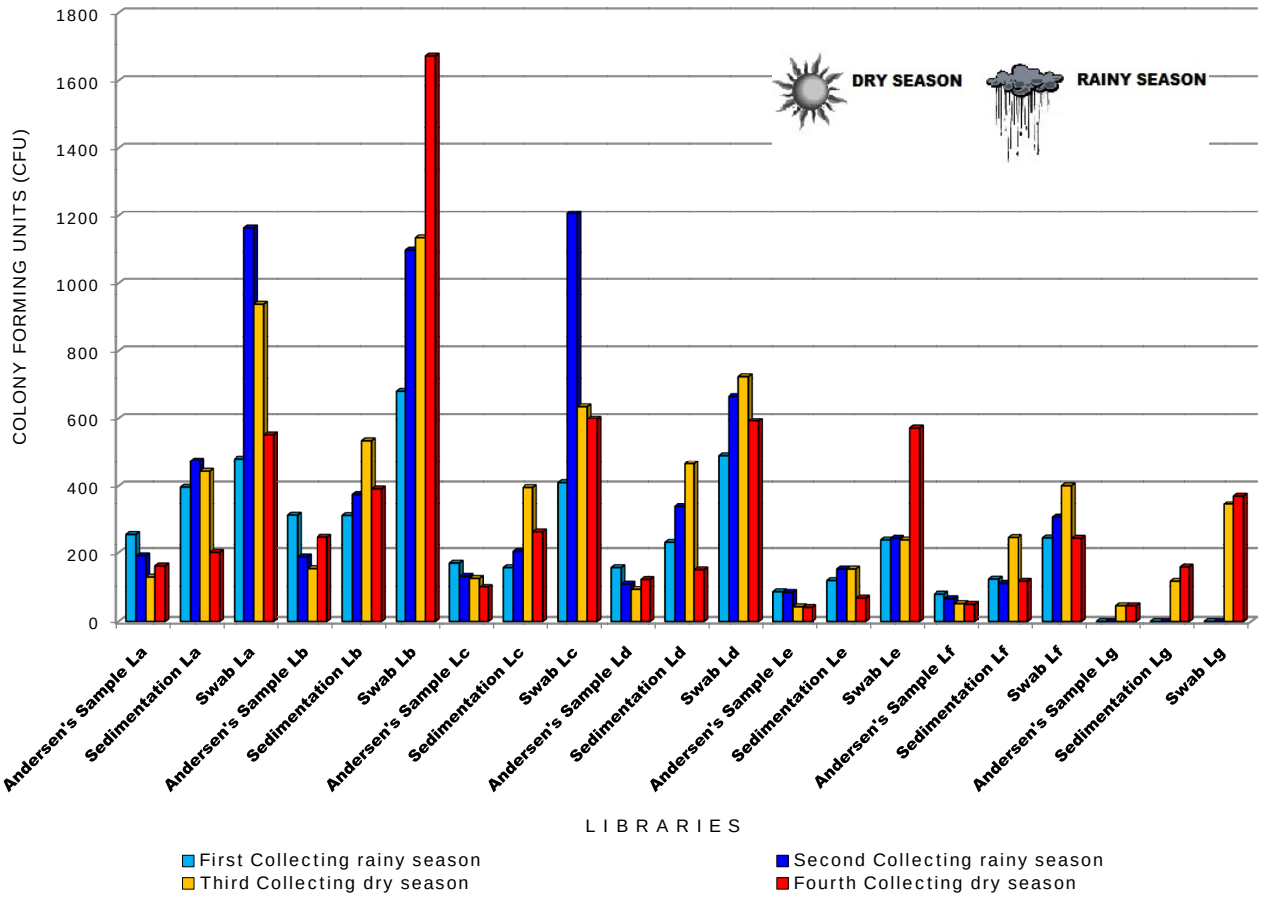



**Figure 2.** Relationship of Colony Forming Units of the three methodologies (swab sterile, sedimentation plate dish and Andersen's sample technique) applied in the four collections, in the dry season and rainy season, in seven libraries in the city Cuiabá and Várzea Grande (MT) in Midwest region of Brazil, in 2014.

Of these, 45 taxa were isolated in the rainy season, of which 18 (33.3%) were exclusive to this season: *Absidia*, *Chaetomium*, *Circinella*, *Cunninghamela*, *Cylindrocarpon*, *Exserohilum*, *Geotrichum*, *Graphium*, *Hanseniospora*, *Hormonema*, *Macrophomina*, *Mariannae*, *Nigrospora*, *Scopulariopsis*, *Scedosporium*, *Trichosporon*, *Tritirachium*, *Ulocladium.* In the dry season, 35 taxa were isolated, of which 9 (16.7%) were exclusive to this season: *Bispora*, *Epicocum*, *Hansenula*, *Monascus*, *Phialophora*, *Rinocladiela*, *Scyncephalastrum*, *Stacybotrys*, *Stemphylium.*

Isolates that did not sporulate were identified as morphotypes (*Mycelia sterilia*), based on their morphological characteristics. Were identified 190 CFU (0.7%) as *Mycelia sterilia* (Agonomycetales) an order of imperfect fungi. The genera with a higher dominance in the total fungi isolated, according to the number of species were: *Aspergillus*, 42 species, 10,628 isolates (40.6%); *Rhodotorula*, 4 species, 2,628 isolates (10%); *Cladosporium*, 8 species, 2,244 isolates (8.6%); Followed by *Cryptococcus* 1,865 isolates (7.1%); *Fusarium* 10 species, 1370 isolates (5.2%); *Penicillium*, 15 species, 1,260 isolates (4.8%); *Paecilomyces*, 7 species, 929 isolates (3.5%); also by *Curvularia*, 7 species; 883 isolates (3.4%); *Alternaria*, 7 species, 832 isolates (3.2%) and *Trichoderma*, 3 species; 536 isolates (2.0%).

Regarding the sociological structure of a species in its totality in the community, indicated that prevalence of the species isolated in this study; we can cite the "*Black Aspergilli*", *Aspergillus niger* 3.219 (12.3%) isolated colonies, followed by lignolytic yeast *Cryptococcus* complex 1865 (7.1%) colonies and the pigmented fungus *Cladosporium cladosporioides* 1825 (7.0%) colonies, as the most commonly isolated in the four collections performed (Table 1).

When we evaluated the prevalence of these fungal entities in relation to each collection, that is, two in the humid season (1st and 2nd collection) and two in the dry season (3rd and 4th collection), we can infer that the three most prevalent species. In the first collect of the wet season, *Aspergillus niger* mycelial fungi predominated 971 (3.7%) CFU, followed by another "*Black Aspergilli*", *Aspergillus awamori* 625 (2.4%) and *Aspergillus flavus* 623 (2.4%) isolates. In the second collect of the wet season, again the predominance of *Aspergillus niger*, this time 878 (3.3%) isolates, followed by the carotenoid yeast *Rhodotorula mucilaginosa* 504 (1.9%) and the anamorph fungus *Penicillium citrinum* 424 (1.6%) isolated.

In the third collect, already destined to the dry season, we observed the presence of the capsulated yeast *Cryptococcus* complex 1129 (4.3%) CFUs, followed by *Aspergillus niger* mycelial fungus 783 (3%) colonies and *Cladosporium cladosporioides* 735 (2.8%) of the isolates and finally in the fourth and final collect, *Rhodotorula glutinis* was predominant 738 (2.8%), followed by mycelial fungi, *Aspergillus niger* 587 (2.2%) isolates and by the darkly pigmented mold *Cladosporium cladosporioides* 574 (2.2%) fungal isolates (Table 1).

### 3.1.2. Species Diversity, Richness and Dominance

The calculated diversity indexes (Table 2) were divided into three groups, ac-

cording to the diversity component they express: those that express richness and diversity (S, $I_{Mg}$, $M_n$), those that analyze the equitability (H') and the one expressing dominance (D').

Among the genera isolated in the dry and rainy season there was a statistically significant difference ($p = 0.023$). The Sörensen similarity index ($S_S$) was 93.2% for the mycotas isolated in both seasons (dry/rainy) showed a high species similarity between the mycotas of the two periods surveyed (dry/rainy). These indices may be considered high, indicating the existence of qualitative differences in the composition of the mycotas isolated, despite the quantitative similarities in the number of species isolated in both seasons.

There was little difference in the richness of fungal species (S), except in the sedimentation technique by petri dish in the rainy season (103), followed by swab in the rainy season (92) (Table 2). It was observed that the greatest number of fungal isolates (CFU) occurred in the dry period.

The diversity and richness of fungi species were characterized by the following indices: The diversity index of Shannon-Wiener (H') was calculated by representing the number of individuals as well as the number of taxa in each site collected. The maximum value of H' was observed by the swab technique in the dry period (H' = 1.47) and in the wet period (H' = 1.31), respectively (Table 2). These results may be indicative that variations in temperature, rainfall and humidity may affect the distribution of species over the periods, since the Shannon-Wiener index expresses species heterogeneity and this heterogeneity seems not to be related only to with different climatic variations.

Simpson's diversity index (1/D) was also studied because it measures the dominant species. Greater dominance was observed, again by the Swab technique (0.0080) during the dry season, while during the wet season it was found (0.0043) (Table 2).

Dominance (D) indicates the dominance of a given species. The value was higher in the Andersen sampler technique (0.0147) during the rainy season and also lower in the rainy season (0.0097) by the sedimentation technique in petri dish. However, the lowest value of (D) was observed in the total values of the rainy season (0.0071). In addition, Fisher's alpha diversity indicated a higher value in the dust samples collected by the technique of exposure in petri dishes in the rainy season (2.66), followed by the swab technique in the rainy season (2.61) (Table 2).

The dominance index of Berger Parker (1/d) expresses the proportion of the total parcel that is due to the dominant species. Compared to sample components at sampling sites with respect to CFU size, the Berger-Parker index of dominance expressed a higher number in the wet period by the Andersen sampler (0.1603) and species samples sharing communities in the plate dish technique in the rainy period and dry period swab (0.1530), respectively.

Margalef ($I_{Mg}$) is index of diversity that also expresses species richness, but weighted by the sample size. Margalef index, which evaluates the diversity of

communities based on the numerical distribution of individuals (CFU) of different genera, depending on the total number of individuals (CFU), our results gave an index of 14.77 in the rainy season and 13.09 in the dry season (Table 2). The richness of species was studied, besides the diversity of Margalef, the Menhinick index was used. The results indicated that the maximum species richness was reported in the dry period by the Andersen's sampler technique and the minimum swab technique, also in the dry period (Table 2).

Table 2. Diversity index of fungi found in the libraries of Cuiabá and Várzea Grande-MT, found in the dust collection of three techniques (Andersen's sampler, exposition of petri dish and sterile swab); during the dry and rainy seasons in 2014.

| Diversity index | Andersen's sample | | Plate dish | | Swab | | Total | |
|---|---|---|---|---|---|---|---|---|
| | dry | rainy | dry | rainy | dry | rainy | dry | rainy |
| Species (S) | 72 | 68 | 84 | 103 | 75 | 92 | 126 | 140 |
| Individuals (N) | 1401 | 1828 | 3572 | 3006 | 9018 | 7369 | 13991 | 12203 |
| Dominance D | 0.0139 | 0.0147 | 0.0119 | 0.0097 | 0.0133 | 0.0109 | 0.0079 | 0.0071 |
| Shannon H' | 0.3491 | 0.4164 | 0.7805 | 0.6660 | 1.4713 | 1.3150 | 2.2682 | 2.0532 |
| Simpson 1/D | 0.0001 | 0.0003 | 0.0007 | 0.0007 | 0.0080 | 0.0043 | 0.0140 | 0.0106 |
| Margaleff ($I_{Mg}$) | 9.7999 | 8.9203 | 10.1456 | 12.7367 | 8.1256 | 10.2189 | 13.0943 | 14.7724 |
| Menhinick ($M_n$) | 4.5953 | 1.5905 | 1.4055 | 1.8786 | 0.7898 | 1.0717 | 1.0652 | 1.2673 |
| Berger-Parker (1/d) | 0.1221 | 0.1603 | 0.0904 | 0.1530 | 0.1530 | 0.1487 | 0.1173 | 0.1515 |
| Fisher (*a*) | 2.4884 | 2.4600 | 2.5649 | 2.6664 | 2.5086 | 2.6102 | 2.7667 | 2.8192 |

### 3.1.3. Occupational Questionnaire

During the collection, an occupational survey was carried out on the staff of the libraries where the parameters related to the condition and wellbeing of employees in the workplace was observed. 71 employees distributed in seven libraries and collections of two cities surveyed participated in the research; (40/56.3%) belonging to the male gender and (31/43.7%) belonging to the female gender, ranging from 15 to 69 years old (mean = 44.7, SD = 15.2, 95% CI % (±3.6)).

Were obtained (50/70.4%) of librarians and collections held a workload equal to 8 hours, and they occupied positions as sector managers, librarians, analysts and administrative assistants. However, (18/25.4%) of the employees had a workload of 6 hours per day, and they were employed by clerks, administrative assistants, security guards, secretaries and trainees. Finally, (3/4.2%) were registered with a workload of 4 hours, occupying the roles of trainees and apprentices.

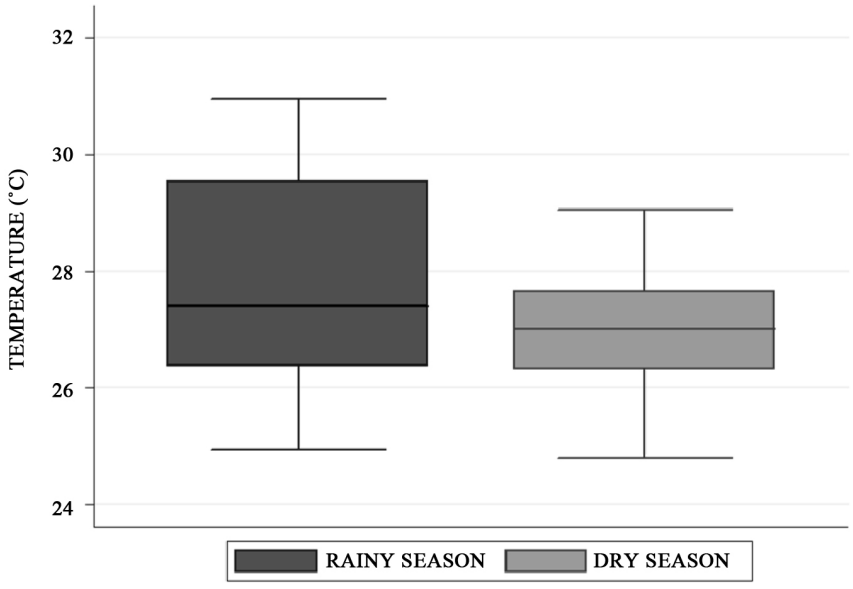
When analyzing the responses of the 71 employees of these literary establishments in the research, it was possible to observe that (18/25.4%) did not report complaints and (53/74.6%) referred to complaints resulting from allergic and respiratory reactions. These were especially reported by employees who worked 8 hours a day (37/52.1%) followed by (16/22.5%) by those who worked 6 hours daily. Of these (32/45.1%) were male and 21/29.5% female.

When asked what type of allergic reaction it was possible to verify that the complaints reported by the employees were mixed and 195 complaints of clinical manifestations were reported; and (85/43.6%) complaints from male individuals and (110/56.4%) complaints from female subjects. The most frequent were: sneezing (29/14.9%); cough (21/10.8%), irritation/clearing (16/8.2%), dry mouth (8/4.1%), coryza (12/6.2%), pruritus (15/7.7%), burning and irritation (14/7.2%), erythema (9/4.6%) and considering the eyes: pruritus (28/14.4%), lacrimation (11/5.6%), burning (19/9.7%), redness (13/6.7%).

### 3.1.4. Internal Climatic Condition

The mean values of the values found for temperature (˚C) within the libraries reached fluctuations in the wet period of (27.6˚C) - SD = 2.1˚C, while in the dry period the recorded temperature was (27.2˚C) - SD = 1.3˚C. Measurements were made in the external areas of these libraries, with the values found in the averages of these temperatures in the wet period (29.1˚C) with SD = 1.3˚C, and in the dry period (26.9˚C) - SD = 1.7˚C (**Figure 3**).

In relation to the relative humidity of the air (RH%) the internal average observing the parameters recommended by the technical norms. In the wet period the unit was equal to 44.5% - SD = 5.7%, while in the dry period 40.3% - SD = 5.4%. In the external areas of the libraries, the mean value for humidity was 58.7% - SD = 4.4% in the wet period and 44.3% - SD = 7.1% in the dry period (**Figure 3**).



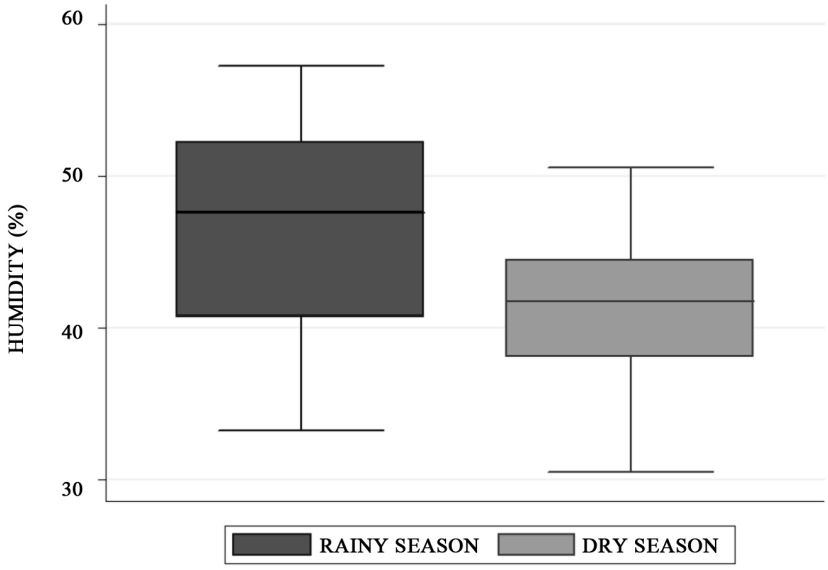



**Figure 3.** Graphical representation showing variation of the internal temperature averages (˚C) graph A and relative air humidity (RH%) graph B, recorded in the dry and humid periods in the seven libraries evaluated in Cuiabá and Várzea Grande-MT-Brazil in 2014.

## 4. Discussion

### 4.1. Fungal Collection

The results obtained showed that the indoor environment of libraries consists of a variety of fungal microrganisms capable of causing deterioration of literary archives, allergic reactions and sensitization in atopic individuals, and possible fungal infections of various etiologies. These findings corroborate studies on airborne mycobiota conducted by several research groups and their casuistic [3] [4] [9] [10] [25] [26].

According [6] [8] [27] modern humans spend an average of 87% of the day indoors; inhaling air contained in these environments. Considering this fact, studies of indoor air quality (IAQ) are important and have been highlighted by several authors in their series, such as those performed in: residences [28], educational institutions [29], hospitals [25] [26], wards [30], laboratory [31], airports [32], railway stations [33]; caves [34]; huts [35]; theaters [36]; wineries [37]; vivarium [38], avian [39], shopping centers, buindings and hotels [40] [41], carpets [42] various internal environmentals [43] and libraries [10] [44] [45].

Fungi are ubiquitous in all environments and the abundance of other fungi varies with time and place. In general, both outer and inner environments are colonized by species of *Cladosporium*, *Penicillium*, *Aspergillus* and *Alternaria* and by yeast and also *Mycelia sterilia*. *Cladosporium* is always the dominant fungus in outdoor environments, but in indoor environments in suitable conditions *Aspergillus* and *Penicillium* are generally dominant [45] [46].

In this work, *Aspergillus* spp. (10,628; 40.6%), one of the main airborne fungi

isolated the world over [21] was isolated in all the collect, being the species *Aspergillus niger* (3219; 12.3%) demonstrating that it is constantly present in numerous locations. According to Prince & Meyer [47] and Miller [48] *Aspergillus* and *Penicillium* are genera that are usually found inside environments, while the concentrations of spores of *Alternaria* spp next to *Cladosporium* spp in the open air are generally more prevalent in the peaks during summer and fall in temperate locations. Other researchers in their casuistic also reported the existence of these fungal entities predominating in the literature records [49] [50]. Aleksic [51], conducting studies on the health risk of mycotoxins produced by fungi growing indoors, have shown numerous light spores that can be easily aerosolized and inhaled along with mycotoxins.

Some studies report the inverse for isolation of the genera *Aspergillus* and *Penicillium*. Sautour [31] conducted a survey of fungal contamination in hospitalar unit, they isolated *Penicillium* spp. (27% - 38%, while Faure [52] conducted a study on airborne microbiota in a French hospital and identified this genus as the most frequent from 1992 to 1999, with a percentage of 28.4%. According to Lacaz [8] find the optimum temperature for greater propagation of the genus *Penicillium* is 20˚C - 25˚C, and this in many places, such as decaying air, soil and organic matter.

According to Pitt [15], this inversion occurs because the species of both genera are found almost everywhere on the planet. *Penicillium* is a common dominant species in cold climates, particularly in cold temperate zones, while *Aspergillus* is most common in the tropics and warm locations. The state of Mato Grosso has a tropical climate and this explains the high rate of isolation of this fungal genre detected in this casuistic.

A number of airborne fungal species are considered important to medical pathologies, including those belonging to the genera *Alternaria* spp., *Aspergillus* spp., *Cladosporium* spp., *Fusarium* spp., *Mucor* spp., *Penicillium* spp. and *Rhizopus* spp. It has become apparent that these are especially allergenic elements, a factor that is particularly disturbing to clinicians, since these microorganisms are abundantly dispersed in the environment. This is the reason that investigations concerning the occurrence of environmental fungi (usually opportunistic and contaminants) have become important in the prevention of allergic diseases caused by pathogens that are potentially harmful to humans [33].

Saprophytic fungi considered common in storage areas, like *Acremonium spp*, *Aspergillus* spp, *Cladosporium* spp, *Curvularia* spp, *Fusarium* spp, *Penicillium* spp and *Rhizopus* spp, presented an expressive quantity of spores in the environments evaluated. These microorganisms are responsible for numerous opportunistic diseases, including onychomycosis, keratitis, ear infections, allergic conditions, mycotoxicosis, as well as urinary, pulmonary and systemic infections.

Dunlap [53] reported that fungi as well as other species of microorganisms on the planet have a circadian clock, and these species differences are more likely to

occur due to environmental changes where the temperature may be slightly warmer in the places or days where they occurred collections, such as during the summer. The findings of Silveira [33] report that there is influence of temperature on the occurrence of species in different climatic periods. Amend [54]; still the humidity can be a differential factor as also the length of the day also changes with the climatic period being able to contribute to the variability and diversity of isolated species. These statements corroborate the results found in this study, indicating that geographically isolated species may belong to the local biota.

It was possible to verify that the most commonly isolated species belonged to the genus *Aspergillus*, *Penicillium*, *Cladosporium*, *Fusarium*, *Paecilomyces*, *Rhodotorula* and *Cryptococcus*, evaluating of cities of Cuiabá and Várzea Grande and the same substrate of the internal dust of libraries of these cities. This fact can signal even with the changes that have taken place in the city's distinctive phytophysiognomy that the species can remain predominant in the place. This citation also complies with Mezzari [55] who report that the anemophilic fungal microbiota may be similar or different in each city or region.

Situations observed in the collection period were the urban works that occurred in both cities due to the advent of the World Cup (2014). The cities Cuiabá and Várzea Grande underwent several changes in infrastructure, such as structural works and construction of road networks, excavations, tunnel construction and a series of changes and transformations, which contributed greatly to the dispersion of dust contained in the soil of the cities surveyed, contributing possibly to increase the isolation of the fungal microorganisms isolated in this work.

Temperate climates favor the appearance of soil fungi, possibly justifying the detection of Cryptococcus (1865; 7.1%) samples in this study. According to Kidd [56] [57], these basidiomycetic yeasts occur at 15 cm from the soil, in trees, wood chips, straw and other "natural reservoirs". This occurs with many other fungi, such as *Aspergillus fumigatus* 182 (0.7%) where their spores are so small, and other species *Aspergillus niger* 3219 (12.3%) and *Aspergillus flavus* 1,618 (6.2%) that any disturbance can dislodge and disperse them via air currents easily aerosolized by soil disturbances [58].

In Brazil, among the main anthropogenic activities that pollute atmospheric air in urban and industrialized regions are the burning of fossil fuels, industrial processes, incineration of urban waste, mining, civil construction and associated inadequate agricultural practices [59].

There is still to be made an inference about the burnings carried out during the dry months in Mato Grosso (August, September and October) in Cerrado areas, which are routinely becoming an event that is already part of the region's phytophysiognomy. This fact is capable of generating constant uncomfortable visual and aggravating health problems common to this period and contributing to the increase of drought and thermal sensation of excessive heat faced by the

population of Mato Grosso state.

In view of the above, these events may have contributed greatly to the capture of fungal spores carried by atmospheric air of the region, facilitating the dispersion of various microorganisms (some considered uncommon in isolation and others considered of extreme importance) in the etiology of respiratory and systemic diseases.

In relation to the yeasts isolated in this study we can highlight those of the genus *Cryptococcus* spp. (1865, 7.1%) which deserve due attention due to possible pathogenicity in immunocompromised and immunocompetent individuals. Fewer are the records of this fungal entity in dust, highlighting the work carried out by Leite-Jr [44], which isolated seven different species of this basidiomycetic yeast being *Cryptococcus neoformans*, *C. gatti*, *C. albidus*, *C. luteolus*, *C. uniguttulatus*, *C. humiculus* and *C. terreus* in the dust of libraries of the Midwest region of the country, highlighting the species *C. gatti* (36.6%), as the agent thinned with this substrate.

A British study established a relationship between the presence of symptoms and an air conditioning system [40]; however, it was in the 1990s that SBS became a common concept in the scientific literature [60]. In Brazil, it only began to receive greater attention from health authorities following the death of the Minister of Communications, Sérgio Motta, in 1998, because his clinical status was aggravated by the presence of fungi growing in the air conditioning system of his cabinet offices.

It is estimated that human inhale about 200 filamentous spores daily containing mycotoxins and fungal volatiles, and some of these compounds react to lung alveoli [58]. The interviews conducted by questions on health and users of mental state allows somehow draw conclusions if the symptoms proposed by SED tend to decrease or disappear when users are away from the building in which they work.

In the seven libraries evaluated, 30 environments were investigated: (10; 33.3%) classified as open environments with air circulation and presence of people constantly; (10, 33.3%) being classified as closed environments, type 1, that maintained air circulation and presence of people; followed by (3; 10%) of closed environments, type 2, with little circulation of air and people and still (7, 23,3%) classified as unhealthy environment, that is, closed and without air circulation and with flow rare of people. It was not possible to make inferences and comparisons between the libraries, due to their size and different dimensions, capacity of support, specific rooms, number of employees, different environments and also the disposition of the environments offered to the public and visitors.

It is important to highlight that when working in libraries, the biological risk of the presence of fungi, bacteria and mites is ever-present, especially on paper, leather, fabric and wood, substrates that these organisms use as their habitat. These risks may be higher or lower depending on the volume and the general

environment, and on the level of monitoring of temperature and relative humidity [9] [61]. Libraries present suitable substrates in the form of old paper, fabrics, dust and glue, in association with the humidity of air conditioners. Workers in these establishments who suffer from allergic rhinitis, asthma and bronchitis can be affected when handling old books, periodicals and documents [3].

Among the mycelial species, four airborne fungi are considered important triggers of respiratory allergies: *Alternaria* spp., *Aspergillus* spp., *Cladosporium* spp. and *Penicillium* spp. The literature describes the importance of these microorganisms and the allergic complications they cause [9] [62] [63]. Several Brazilian research groups have reported, in their respective casuistics, symptoms that these agents trigger in people who are prone to allergies [25] [26] [45].

The sensitization of individuals occurs through exposure to fungi and due to their high molecular weight, these microorganisms possess an antigenic capacity caused by different substances embedded within their structure that promote a variety of reactions [55] [64].

According Gioda and Aquino Neto [4], the causes of SBS can be explained by a number of factors, including a lack of fresh air, poor air distribution, poor temperature control, inadequate design and irregular air conditioning system maintenance. Thus, not only is it problematic to characterize SBS in a particular building, it is also difficult to identify the primary cause.

Several researchers have conducted surveys concerning the health and mental state of occupants and any symptoms manifested while remaining inside and while outside these buildings as an effective way to identify SBS [4]. It is known that the impact of remaining inside establishments with high concentrations of microorganisms and poor moisture control, allied with work, physical fatigue and stress factors are perceived by the body and mind, leading to symptoms known as allergies or skin problems. The importance of microbiota in libraries worldwide was reviewed by Gallo [62]. In his research, he affirmed that the cause of this problem could be dust or components that affix to the books and shelving.

Allergic rhinitis at present represents a global public health problem and affects 10% to 25% of the population in Western countries. The prevalence of allergic rhinitis in Brazil is not known, although studies conducted in the 80% decade indicate an estimate of 15%. In the 1990s, studies (International Study of Asthma and Allergies in Childhood-ISAAC) showed a prevalence of 30% in children and adolescents. In adults, it is possible that this prevalence reaches 20% or more [65]. In 2011, in a study conducted by Indian researchers, led by Sathavahana Chowdary [66] found a prevalence of 44% in its casuistry.

According WHO [5], occupants of buildings with moisture problems and containing fungal growth are at higher risk of contracting respiratory diseases, including infectious diseases. This information suggests that in these conditions considered to be often unhealthy, the risk of developing diseases such as allergic rhinitis and asthma can be increased. Kleinheinz & Campbell [67] in their studies also stated that allergic reactions may be related to the presence of certain

fungi or portions of fungi in indoor air or associated with extracellular compounds produced. French researcher [51] affirm the presence of mycotoxins in indoors should be taken into consideration as an important parameter of air quality, that part of the toxic load was found on very small particles—dust or tiny fragments, that could be easily inhaled.

In this research, when the employees were questioned about the clinical and epidemiological investigation of the work environment, it was possible to verify that (20/28.2%) of the interviewees reported complaints due to rhinitis in the work environment. Asthma (5/7%) referred to the effects of this reaction and (8/11.2%) as a consequence of sinusitis and finally, (20/28.2%) referred to another type of infection.

Since 2002, the Occupational Safety and Health Administration (OSHA) in the United States has been delivering documented results on the effects of asthma on workers in commercial and institutional environments, revealing the presence of fungi in these workplaces. OSHA research has shown that fungi can cause skin irritation and have effects on the cardiovascular, pulmonary, nervous, reproductive, and carcinogenic effects [68].

However, according to Hess-Kosa [69] SED is defined only if the presence of these symptoms occurs in a significant number of people. The presence of similar symptoms among the occupants of the building is of extreme importance for the detection of SED [70].

In the city of New Delhi [71] and Brazil [4] cited polls with users of buildings as an effective way of identifying SED. According to WHO standards, more than half of the indoor environments of buildings such as schools, hospitals, residences, movies, theaters, shopping centers, show poor air quality and suggest that occupants of 30% of new or refurbished buildings around the world presented complaints compatible with poor indoor air quality [5].

Based on the results of the individual surveys applied to Mato Grosso state library staff, it was possible to verify the most prevalent symptoms. In this case the percentage of individuals is equal to or greater than 20%, this will be a strong indicator of the existence of SBS among the occupants of the building, as suggested [5].

Few studies show the association between SBS and the age of individuals in 2013 [72]. In China, demonstrated that Adults' SBS symptoms are associated with a history of asthma, allergic rhinitis or eczema. This fact proves that the manifestations provoked by inhalation of bioaerosols, provoking asthma and rhinitis can affect any age. These results are in accordance with the findings [73] [74].

Our results showing considering the employees, that (18/25.4%) reported no complaints regarding allergic manifestations and (53/74.6%) reported some allergic manifestations during the working day. Among the 53 employees who reported allergic discomfort (34/64.2%) were enrolled in the age group below 44 years of age, reflecting those who reported more problems related to occupa-

tional activity and irritations due to their stay in work environments; (19/35.8%) remained in the age group above 44 years.

Evaluated the internal air [75] of environments, it was found that females (44.3%) were more susceptible to inhaled infections than males (26.2%). It was possible to verify in this study that, although women (31/43.7%) represented a lower index than men (40/56.3%), they reported more complaints of symptomatology (110/56.4%) compatible with SBS compared to men (85/43.6%). This finding confirms previous reports which have indicated the female gender as the most susceptible to this problem, corroborating with results found in this study with the reports [76].

In 2005 [75] also revealed that women are seen as strong candidates to present significant risks of perceiving eye symptoms. Other researchers consider IAQ as one of the main determinants of SBS [76].

Studies showed [76] [77] [78] [79] [80] that considering gender, there is a greater impact factor on women's health. According Kinman & Griffin [81] the results are not unequivocal and many studies include the possibilities that women may be more sensitive to environmental factors.

Others researchers [77] reported differences in the occurrence of SBS symptoms between women and men resulting in factors external to the internal environment. However [79] suggested when evaluating 1,024 adolescents of both genders that higher endogenous estrogen levels in sexually mature adolescents appear to protect them against the effects of aeroallergens, although their overall prevalence is considered to be higher. Bell [82] also point out in their research that women are more susceptible to SBS due to higher estrogen/progesterone ratios. Hormone levels play an important role in neural sensitization because of prolonged and repeated exposure to external stimuli.

The Brazilian Association of Technical Standards (1980) cites that the relative humidity of the air recommended for the deposit of manuscripts and rare works is between 40% to 50% and the temperature is between 21˚C to 23˚C and values above this can cause damage to the collection. The resolution RE n˚9, January 16, 2003 [83] advocates these same parameters [84]. Additionally [84] reports that for good chemical and physical paper conservation, it is advisable to maintain a temperature between 18˚C and 22˚C and relative humidity between 45 and 55%.

Cassares & Moi [85] reported that it is more recommended to keep the archives and libraries at a temperature closer to 20˚C and relative humidity at 45% to 50%, avoiding in any way the oscillations of 3˚C temperature and 10% relative humidity.

Arundel [86] have suggested that high RU increases the occurrence of allergic diseases and respiratory infections. Humidity between 40% and 70% minimizes bacterial and fungal infections, and most fungal species do not grow in RU less than 60%.

There seems to be a divergence between the authors regarding the levels of

temperature and humidity fluctuations reported by several authors. In this way, it is possible to conclude that the desirable values according to the mentioned authors, can be between 18˚C and 23˚C considering the temperature and 40 to 60% for humidity.

Costa [84] emphasizes that the imbalance of temperature and relative humidity causes in the collection a dynamics of contraction and elongation of the elements that compose the paper besides favoring the proliferation of biological agents, such as: fungi, bacteria, insects and rodents. The lower the temperature, the longer the paper stays and the longer it lasts. Moisture also greatly affects the paper as follows if very high, accelerates acid degradation and if it is too low, facilitates the attack of biological agents.

The differences in the results between this and other studies can be attributed to geographical location, climatic period, abiotic factors and the time and methodology of collection, since the techniques used in this study may differ greatly compared with other techniques. It is also clear that abiotic factors, such as temperature and relative humidity, exert an important influence on CFUs. This observation is fully corroborated Samson [14], who pointed out that fungi only occur under favorable conditions, which vary for each species, and that adaptability is a determining factor.

## 5. Conclusions

These results show that the air conditioning systems of the libraries were not able to maintain the temperature and the relative humidity of the air in the evaluated environments causing high temperature oscillation inside the same ones and thus providing risk factors for the collection favoring the proliferation of fungi which can trigger allergic and respiratory problems.

The internal conditions found in the studied libraries (relative humidity, temperature, conservation of the collections, dust, books, atmospheric air pollution, etc.) in this study, found non ideal values, in the matter of conservation of the stocked materials. These researched libraries need to be applied conservation and cleaning methodologies to optimize the conditions of internal environments. In particular, with regard to questions of relative humidity and internal temperature fluctuations, special care should be taken to avoid the proliferation of fungal agents.

Hygiene, conservation and air quality care are effective conditions for resolving an IAQ problem, especially where the sources are opportunistic microorganisms that settle in those places where heat, darkness and humidity coexist, and these known sources can be controlled. Periodic cleaning, maintenance of air conditioners and air conditioning in the interiors, as well as the use of dehumidifiers help to provide adequate conditions in these environments and all can be performed individually or at the same time.

Internal air quality management and control programs, aided in the orientation and education of users, employees and technical part of these study and

knowledge establishments; become important tools in the prevention and proper functioning of these sites and consequently minimization of problems related to Sick Building Syndrome.

In summary, this study showed clear evidence of fungal diversity in the libraries evaluated and indicated that more effective methods of disinfection and sterilization are required to combat these potentially pathogenic fungal organisms.

## Acknowledgements

Financial support for this study was provided by the Research Foundation of the State of Mato Grosso (*Fundação de Amparo à Pesquisa no Estado de Mato Grosso*, FAPEMAT) and Coordination of Improvement of Higher Level Personnel (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*, CAPES).

## Author Contributions

Diniz Pereira Leite Júnior was the researcher-in-chief, and designed and performed the study. Diniz Pereira Leite Júnior and Rosane Christine Hahn drafted the study. All authors collected and examined the biological samples, performed the experiments and all authors contributed to data analysis. Diniz Pereira Leite Júnior wrote the paper, and all authors made critical revisions and approved the final manuscript.

## Conflicts of Interest

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results. The authors declare there are no conflicts of interest.

## References

[1] Hibbett, D.S., Ohman, A., Glotzer, D., Nuhn, M., Kirk, P. and Nilsoon, R.H. (2011) Progress in Molecular and Morphological Taxon Discovery in Fungi and Options for Formal Classification of Environmental Sequences. *Fungal Biology Reviews*, **25**, 38-47. https://doi.org/10.1016/j.fbr.2011.01.001

[2] Brasil (2017) Brazilian Biodiversity. Ministry of the Environment. http://www.mma.gov.br/biodiversidade/biodiversidade-brasileira

[3] Singh, A., Ganguli, M. and Singh, A.B (1995) Fungal Spores Are an Important Component of Library Air. *Aerobiologia*, **11**, 231-237. https://doi.org/10.1007/BF02447203

[4] Gioda, A. and Aquino Neto, F.R. (2003) Comments on Studies of Industrial and Non-Industrial Environments in Brazil: A Comparative Approach. *Public Health Journal*, *Rio de Janeiro*, **19**, 1389-1397.

[5] WHO. World Health Organization (2012) Guidelines for Indoor Air Quality: Selected Pollutants. http://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf

[6] Junker, M., Koller, T. and Monn, C. (2000) An Assessment of Indoor Air Contaminants in Buildings with Recreational Activity. *Science of the Total Environment*, **246**, 139-152. https://doi.org/10.1016/S0048-9697(99)00452-0

[7] Mato Grosso (2018) Government of Mato Grosso. Transparency Portal. http://www.mt.gov.br/geografia

[8] Lacaz, C.S., Porto, E., Martins, J.E.C., Heins-Vaccari, E.M. and Mello, N.T. (2002) Treaty of Medical Mycology Lacaz. 9ª Edição. Savier, São Paulo.

[9] Gambale, W., Croce, J., Costa-Manso, ER., Croce, M. and Sales, M. (1993) Library Fungi at University of São Paulo and Their Relationship with Respiratory Allergies. *Journal Investigational Allergology and Clinical Immunology*, **3**, 45-50.

[10] Reis-Menezes, A.A., Gambale, W. and Giudice, M.C. (2011) A Survey of Fungal Contamination on Books in Public Libraries with Mechanical and Natural Ventilation. *Indoor Bult Environmental*, **20**, 393-399. https://doi.org/10.1177/1420326X11409449

[11] Andrade, N.J. (2008) Hygiene in the Food Industry: Evaluation and Control of the Adhesion and Formation of Bacterial Biofilms. Ed. 01. Varela, São Paulo, 412 p.

[12] Baird, R.B., Eaton, A.D. and Rice, E.W. (2017) Apha-American Public Health Association. Standard Methods for the Examination of Water and Wastewater. 23rd Edition, APHA (American Public Health Association)/AWWA (American Water Works Association), New York.

[13] Klich, M.A. (2002) Biogeography of *Aspergillus* Species in Soil and Litter. *Mycology Lawrence*, **94**, 21-27. https://doi.org/10.1080/15572536.2003.11833245

[14] Samson, R.A., Hoekstra, E.S., Frisvad, J.C. and Filtenborg, O. (2002) Introduction to Food and Airborne Fungi. 6th Edition, Centraalbureau Voor Schimmelcultures, Utrecht, 389 p.

[15] Pitt, J.I. (2000) A Laboratory Guide to Common *Penicillium* species. Food Science Australia a Joint Venture of CSIRO, Australia, AFISC, 197 p.

[16] Nelson, P.E., Tousson, T.A. and Marasas, W.F.O. (1983) *Fusarium* Species: An Illustrated Manual for Identification. The Pennsylania State University Press, University Park, London, 123.

[17] Kwong-Chung, K.J. and Bennet, J.E. (1993) Medical Mycology. Lea & Febiger, Philadelphia, 866 p.

[18] Pitt, J.I. and Hocking, A.D. (2009) Fungi and Food Spoilage. 3rd Edition, Springer Dordrecht Heidelberg London New York Cambridge, 519 p. https://doi.org/10.1007/978-0-387-92207-2

[19] Samson, R.A. and Varga, J. (2007) *Aspergillus* Systematic in the Genomic Era. Studies in Mycology 59. CBS Fungal Biodiversity Centre, Utrecht, 207 p.

[20] Lacaz, C.S, Porto, E., Heins-Vacarri, EM. and Mello, N.T. (1988) Guide for Identification: Fungi, Actinomycetes and Algae of Medical Interest. Sarvier-Fapesp, São Paulo.

[21] Klich, M.A. (200b) Identification of Common *Aspergillus* Species. The Centrallbureau voor Shcimmelcultures, Utrecht, The Netherlands. An Institute of the Royal Netherlands Academy of Arts and Science.

[22] Watanabe, T. (2002) Pictorial Atlas of Soil and Seed Fungi—Morphologies of Cultured Fungi and Key to Species. 2nd Edition, CRC Press, 486. https://doi.org/10.1201/9781420040821.bmatt3

[23] Samson, R.A. and Frisvad, J.C. (2004) *Penicillium* Subgenus *Penicillium*: New Tax-

onomic Schemes, Mycotoxins and Other Extrolites. *Studies in Mycology*, **49**, 1-251.

[24] Neto, P.L.O.C. (1977) Estatística. Ed. Blucher Ltda.

[25] Flores, L.H. and Onofre, S.B. (2010) Determination of the Presence of Anemophilous Fungi and Yeast at a Health Unit of Francisco Beltrão City (PR). *Journal of Health and Biology*, **5**, 22-26.

[26] Simões, S.A.A., Leite-Jr., D.P. and Hahn, R.C. (2011) Fungal Microbiota in Air-Conditioning Installed in Both Adult and Neonatal Intensive Treatment Units and Their Impact in Two University Hospitals of the Central Western Region, Mato Grosso, Brazil. *Mycopathologia*, **172**, 109-116. https://doi.org/10.1007/s11046-011-9411-0

[27] Klepeis, N.E., Nelson, W.C., Waune, R.O., Robinson, J.P., Tsang, A.M., Switzer, P., Bhar, J.V., Hern, S.C. and Elgelmann, W.H. (2001) The National Human Activity Pattern Survey (NHAPS): A Resource for Assessing Exposure to Environmental Pollutants. *Journal of the Experimental Analysis Envirolmental Epidemiology*, **11**, 231-252.

[28] Cartaxo, E.F., Gonçalves, A.C.L.C., Costa, F.R., Coelho, I.M.V. and Santos, J.G. (2007) Aspectos de contaminação biológica em filtros de condicionadores de ar instalados em domicílios da cidade de Manaus (AM). *Engenharia Sanitaria e Ambiental*, **12**, 202-211. https://doi.org/10.1590/S1413-41522007000200011

[29] Degobbi, C., Lopes, F.D.T.Q.S., Carvalho-Oliveira, R., Munoz, J.E. and Saldiva, P.H.N. (2011) Correlation of Fungi and Endotoxin with Pm2.5 and Meteorological Parameters in Atmosphere of Sao Paulo, Brazil. *Atmospheric Environment*, **45**, 2277-2283. https://doi.org/10.1016/j.atmosenv.2010.12.005

[30] Richardson, M.D., Rennie, S., Marshall, I., Morgan, M.G., Murphy, J.A., Shankland, G.S., Watson W.H. and Soutar, R.L. (2000) Fungal Surveillance of an Open Haematology Ward. *Journal Hospital Infection*, **45**, 288-292. https://doi.org/10.1053/jhin.2000.0780

[31] Sautour, M., Fournel, I., Dalle, F., Calinon, C., L'ollivier, C., Goyer, M., Cachia, C., Aho, S., Sixt, N., Vagner, O., Cuisenier, B. and Bonnin, A. (2012) Dynamics of Fungal Colonization in a New Medical Mycology Laboratory. *Journal Mycological Medicine*, **22**, 14-20. https://doi.org/10.1016/j.mycmed.2011.11.001

[32] Silveira, M.G. (2002) Concentration of Fungi in the Air at an Airport Terminal in the City of Rio de Janeiro, Brazil. *Brazilian Journal of Occupational Health*, **27**, 111-120.

[33] Kawasaki, T., Kyotani, T., Ushiogi, T., Izumi, Y., Lee, H. and Hayakawa, T. Distribution and Identification of Airborne Fungi in Railway Stations in Tokyo, Japan. *Journal Occupational Health*, **52**, 186-193. https://doi.org/10.1539/joh.O9022

[34] Docampo, S., Trigo, M.M., Recio, M., Melgar, M., Garcia-Sanchez, J. and Cabezudo, B. (2011) Fungal Spore Content of the Atmosphere of the Cave of Nerja (Southern Spain): Diversity and Origin. *Science Total Environmental*, **409**, 835-843. https://doi.org/10.1016/j.scitotenv.2010.10.048

[35] Duncan, S.M., Farrell, R.L., Jordan, N., Jurgens, J.A. and Blanchette, R.A. (2010) Monitoring and Identification of Airborne Fungi at Historic Locations on Ross Island, Antarctica. *Polar Science*, **4**, 275-283. https://doi.org/10.1016/j.polar.2010.03.008

[36] Kelkar, U., Bal, A.M. and Kulkarni, S. (2005) Fungal Contamination of Air Conditioning Units in Operating Theatres in India. *Journal Hospital Infection*, **60**, 81-84. https://doi.org/10.1016/j.jhin.2004.10.011

[37] Haas, D., Galler, H., Habib, J., Melkes, A., Schlacher, R., Buzina, W., Friedl, H., Marth, E. and Reithaler, F. (2010) Concentrations of Viable Airborne Fungal Spores and Trichloroanisole in Wine Cellars. *International Journal Food Microbiology*, **144**, 126-132. https://doi.org/10.1016/j.ijfoodmicro.2010.09.008

[38] Lobato, R.C., Danielski, J.C.R. and Silveira, E.S. (2007) Research of Anemophilous Fungi in an Biotery. *Vittale*, **19**, 9-16.

[39] Gigli, A.C.S.I., Baracho II, M.S.I., Nääs, I.A.I., Silva, R.A.I., Zago, R.I. and Dall'Anese, F.P.I. (2005) Diagnosis and Evaluation of Fungi Presence in the Air of Two Different Ventilation Sytems for Broiler Houses. *Brazilian Journal of Poultry Science*, **7**, 205-208.

[40] Ricard, I. (1998) Evaluation and Identification of Fungus in Breathable Dust in Conventional Shed for Broiler Chickens. *Brasindoor*, **3**, 28-29.

[41] Norback, D. and Cai, G. (2011) Fungal DNA in Hotel Rooms in Europe and Asia-Associations with Latiyude, Precipitation, Building Data, Room Characteristics and Hotel Ranking. *Journal Environmental Monitoring*, **13**, 2903-2995. https://doi.org/10.1039/c1em10439j

[42] Hamada, N. and Fujita, T. (2002) Effect of Air-Conditioner on Fungal Contamination. *Atmospheric Environmental*, **36**, 5443-5448. https://doi.org/10.1016/S1352-2310(02)00661-1

[43] Chakraborty, S., Sen, S.K. and Bhattacharya, K. (2000) Indoor and Outdoor Aeromycological Survey in Burdwan, West Bengal, India. *Aerobiologia*, **16**, 211-219. https://doi.org/10.1023/A:1007644300296

[44] Leite-Jr., D.P., Amadio, J.V.R.S., Martins, E.R., Simões, S.A.A., Yamamoto, A.C.A., Leal-Santos, F.A., Takahara, D.T. and Hahn, R.C. (2012a) *Cryptococcus* spp Isolated from Dust Microhabitat in Brazilian Libraries. *Journal Occupational Medicine and Toxicology*, **7**, 11. https://doi.org/10.1186/1745-6673-7-11

[45] Leite-Jr., D.P., Yamamoto, A.C.A., Amadio, J.V.R.S., Martins, E.R., Leal-Santos, F.A., Simões, S.A.A. and Hahn, R.C. (2012b) Trichocomaceae: Biodiversity of *Aspergillus* spp *and Penicillium* spp Housed in the Internal Environment of Libraries. *Journal Infection Developing Countries*, **6**, 734-743.

[46] Dacarro, C., Picco, A.M., Grisoli, P. and Redolfi, M. (2003) Determination of Aerial Microbiological Contamination in Scholastic Sports Environment. *Journal Applied Microbiology*, **95**, 904-912. https://doi.org/10.1046/j.1365-2672.2003.02044.x

[47] Prince, H.E. and Meyer, G.H. (1976) An Up-to-Date Look at Mold Allergy. *Annals of Allergy*, **37**, 18-25.

[48] Miller, J.D. (1992) Fungi as Contaminants in Indoor Air. *Atmospheric Environmental*, **26**, 2163-2172. https://doi.org/10.1016/0960-1686(92)90404-9

[49] Chadeganipour, M., Ojghi, R., Rafiei, H., Afshar, M. and Hashemi, S.T. (2013) Bio-Deterioration of Library Materials: Study of Fungi Threatening Printd Materials of Libraries in Isfahan University of Medical Sciences in 2011. *Jundishapur Journal Microbiology*, **6**, 127-131. https://doi.org/10.5812/jjm.4751

[50] Hayleeyesus, S.F. and Manaye, A.M. (2014) Microbiological Quality of Indoor Air in University Libraries. *Asian Pacific Journal Tropical Biomedicine*, **4**, 312-317. https://doi.org/10.12980/APJTB.4.2014C807

[51] Aleksic, B., Draghi, M., Ritoux, S., Bailly, S., Lacoroix, M., Oswald, I.P., Bailly, J.D. and Robine, E. (2017) Aerosolization of Mycotoxins after Growth of Toxinogenic Fungi on Wallpaper. *Applied Environmental Microbiology*, **83**. https://doi.org/10.1128/AEM.01001-17

[52] Faure, O., Fricker-Hidalgo, H., Lebeau, B., Mallaret, M.R., Ambrosie-Thomas, P. and Grillot, R. (2002) Eight-Year Surveillance of Environmental Fungal Contamination in Hospital Operating Rooms and Haematological Units. *Journal Hospital Infection*, **50**, 155-160. https://doi.org/10.1053/jhin.2001.1148

[53] Dunlap, J., Loron, J.J. and Decoursey, P.J. (2004) Chronobiology: Biological Timekeeping. Sinauer Associates, Inc., Sunderland, Massachusetts, 67-105.

[54] Amend, A.S., Seifert, K.A., Samson, R. and Bruns, T.D. (2010) Indoor Fungal Composition is Geographically Patterned and More Diverse in Temperate Zones than in the Tropics. *Proceedings of the National Academy of Sciences of the United Stantes of America*, **107**, 13748-13753. https://doi.org/10.1073/pnas.1000454107

[55] Mezzari, A., Perin, C., Santos-Junior, A.S., Guerra, B. and Di Gesu, G. (2003) Airborne Fungi and Sensitization in Atopic Individuals in Porto Alegre, RS, Brazil. *Journal of the Brazilian Medical Association*, **49**, 270-273.

[56] Kidd, S.E., Guo, H., Bartlett, KH., Xu, J. and Kronstad, J.W. (2005) Comparative Gene Genealogies Indicate that Two Clonal Lineages of *Cryptococcus gattii* in British Columbia Resemble Strains from Other Geographical Areas. *Eukaryot Celler*, **4**, 1629-1638. https://doi.org/10.1128/EC.4.10.1629-1638.2005

[57] Kidd, S.E., Bach, P.J., Hingston, A.O., Mak, S., Chow, Y., Macdougall, L., Kronstad, J.W. and Bartlett, K.H. (2007) *Cryptococcus gattii* Dispersal Mechanisms, British Columbia, Canada. *Emerging Infectious Diseases*, **13**, 51-57. https://doi.org/10.3201/eid1301.060823

[58] Latge, J.P. (1999) *Aspergillus* Fumigatus and Aspergillosis. *Clinical Microbiology Reviews*, **12,** 310-350.

[59] Souza, P.A., Mello, W.Z., Mariani, R.L. and Sella, S.M. (2010) Characterization of the Fine and Coarse Particulate Matter and Composition of the Water Soluble Fraction in São José dos Campos (SP). *New Chemistry*, **33**, 1247-1253.

[60] Brickus, L.S.R. and Aquino Neto, F.R. (1999) Indoor Air Quality and Chemistry. *New Chemistry*, **22**, 65-74.

[61] Valentin, N., Garcia. R.D.E., Luis, O. and Maekawa, S. (1998) Microbial Control in Archives, Libraries and Museums by Ventilation Systems. *Restaurator Journal*, **19**, 85-107. https://doi.org/10.1515/rest.1998.19.2.85

[62] Gallo, F. (1993) Aerobiological Research and Problems in Libraries. *Aerobiologia*, **9**, 117-130. https://doi.org/10.1007/BF02066253

[63] Menezes, E.A., Alcantor, A.C. and Cunha, F.A. (2006) Airborne Fungi in the Periodics Room of the Library of Health Science of the University Federal of Ceará. *Brazilian Journal of Clinical Analysi*, **38**, 155-158.

[64] Pecher, A.S., Castro, G.B. and Borras, M.R.L. (1988) Survey about Anemophilus Fungi in Brazilian Colombian Border. *Journal of Brazilian Society Tropical Medicine of São Paulo*, **21**, 63-66.

[65] Hamilos, D.L. (2010) Allergic Fungal Rhinitis and Rhinosinusitis. *Proceeding of American Throraci Society*, **7**, 245-252. https://doi.org/10.1513/pats.200909-098AL

[66] Sathavahana Chowdary, V., Lakshmi, P., Sangram, V., Sudha, R. and Vinay Kumar, E.C. (2011) Role of Fungi (Molds) in Allergic Airway Disease—An Analysis in a South Indian Otolaryngology Center. *Indian Journal Allergy Asthma Immunology*, **25**, 67-78.

[67] Kleinheinz, G.T. and Campbell, A. (2017) Seasonal Impacts on Indoor Fungal Concentrations after Mold Remediation. *Journal Earth Science Environmental Studies*, **2**, 1-11.

[68] Osha (2011) Occupational Safety and Health Administration, US Department of Labor. Indoor Air Quality in Institutional and Commercial Building. https://www.osha.gov/Publications/-3430indoor-air-quality-sm.pdf

[69] Hess-Kosa, K. (2002) Indoor Quality: Sampling Methodologies. CRC Lewis Publishers, Boca Raton, 320 p.

[70] Redlich, C.A., Sparer, J. and Cullen, M.R. (1997) Occupational Medicine: Sick Building Syndrome. *The Lancet*: *UK Medical Journal*, **349**, 1013-1016.

[71] Gupta, S., Khare, M. and Goyal, R. (2007) Sick Building Syndrome—A Case Study in a Multistory Centrally Air-Conditioned Building in the Delhi City. *Building and Environment*, **42**, 2797-2809. https://doi.org/10.1016/j.buildenv.2006.10.013

[72] Wang, J., Baizhan, L., Yang, Q., Wang, H., Norback, D.V. and Sundell, J. (2013) Sick Building Syndrome among Parents of Preschool Children in Relation to Home Environment in Chongqing, China. *Chinese Science Bulletin*, **58**, 4367-4376. https://doi.org/10.1007/s11434-013-5814-2

[73] Li, L., Adamkiewicz, G., Zhang, Y., Spengeler, D.K., Qu, F. and Sundell, J. (2015) Effect of Traffic Exposure on Sick Building Syndrome Symptoms among Parents/Grandparents of Preschool Children in Beijing, China. *PloS One*, **10**, e0128767. https://doi.org/10.1371/journal.pone.0128767

[74] Qian, H., Zheng, X., Zhang, M., Weschler, L. and Sundell, J. (2016) Associations between Parents' Perceived Air Quality in Homes and Health among Children in Nanjing, China. *Plos One*, **11**, e0155742. https://doi.org/10.1371/journal.pone.0155742

[75] Brasche, S., Bullinger, M., Petrovitch, A., Hardt, H., Herzog, V. and Bischof, W. (2005) Symptoms and Related Diagnostic Find of Risk Factor Profiles. *Indoor Air*, **15**, 56-64. https://doi.org/10.1111/j.1600-0668.2005.00358.x

[76] Joshi, S.M. (2008) The Sick Building Syndrome. *Indian Journal Occupational Environmental Medicine*, **12**, 61-64. https://doi.org/10.4103/0019-5278.43262

[77] Steinberg, B. and Wall, S. (1995) Why Do Women Reporte "Sick Building Syptoms" More Often than Men. *Social Science & Medicine*, **40**, 491-502.

[78] Skyberg, K., Skulber, K.R., Eduard, W., Skaret, E., Levy, F. and Kjuus, H. (2003) Symptons Prevalence among Office Employees and Associations to Building Characteristics. *Indoor Air*, **13**, 246-252. https://doi.org/10.1034/j.1600-0668.2003.00190.x

[79] Meyer, H.W., Würtz, H., Suadicani, P., Gaard, T.O. and Gyntelber, F. (2004) Molds in Floor Dust and Building-Related Symptoms I Adolescent School Children. *Indoor Air*, **14**, 65-72. https://doi.org/10.1046/j.1600-0668.2003.00213.x

[80] Runeson, R., Wahlstedt, K., Wieslander, G. and Norback, D. (2006) Personal and Psychosocial Factors and Sumptoms Compatible with Sick Building Syndrome in the Swedish Workforce. *Indoor Air*, **16**, 445-453. https://doi.org/10.1111/j.1600-0668.2006.00438.x

[81] Kinman, G. and Griffin, M. (2008) Psychosocial Factors and Gender as Predictors of Symptoms Associated with Sick Building Syndrome. *Stress and Health*, **24**, 165-171. https://doi.org/10.1002/smi.1175

[82] Bell, I., Baldwin, C., Russek, L., Schwartz, G. and Hardin, E. (1998) Early Life Stress, Negative Paternal Relationships, and Chemical Intolerance in Middle Aged Women: Support for a Neural Sensitization Model. *Journal Women's Health*, **7**, 1135-1149. https://doi.org/10.1089/jwh.1998.7.1135

[83] Brasil (2003) Ministry of Health. National Health Surveillance Agency (ANVISA).

Resolução n. 9 de 16 de janeiro de 2003. Determines the Publication of Technical Guidance Prepared by Technical Advisory Group on Reference Standards for Indoor Air Quality in Artificially Air-Conditioned Environments for Public and Collective Use.
http://www.ctpconsultoria.com.br/pdf/Resolucao-RE-ANVISA-009-de-16-01-2003.pdf

[84] Costa, M.F. (2003) Basic Concepts of Preventive Document Conservation. Center for Scientific and Technological Information (CICT)-Manguinhos Library-Laboratory for Preventive Document Conservation, Ministry of Health, FIOCRUZ (Oswaldo Cruz Foundation), 14.

[85] Cassares, N.C. and Moi, C. (2000) How to Do Preventive Conservation in Archives and Libraries. Vol. 5. State Archives/Official Press. São Paulo, 80 p.

[86] Arundel, A.V., Sterling, E.M., Biggin, J.H. and Sterling, T.D. (1986) Indirect Health Effects of Relative Humidity in Indoor Environments. *Environmental Health Perspective*, **65**, 351-361.
https://ehp.niehs.nih.gov/wp-content/uploads/65/ehp.8665353.pdf