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Fungi Isolated from Cattle Potentially Causing Economic Losses in the Production Chain: Retrospective Data

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ABSTRACT

***Background*:** Fungal diseases in bovines might cause considerable economic losses for farmers and the livestock industry due to decreased productivity caused by various factors. The most important causes described in the literature are: direct infections, secondary complications like reduced growth productivity and reproduction, weight loss, decreased milk production, production of mycotoxins, treatment costs, and even mortality. The purpose of this manuscript is to describe a retrospective data about fungal isolated from bovines at the Sector of Veterinary Mycology, School of Veterinary Medicine of the Federal University of Rio Grande do Sul (UFRGS) during a 38-year period of routine diagnosis (1986-2023).
***Materials, Methods & Results*:** Two-hundred and thirty-two (n = 232) mycological cultures were made from bovine samples from specimens of various systems [integumentary (n = 84); 27 respiratory (n = 27); reproductive (n = 41) and digestive (n = 36)] and 44 samples of quarter milk from subclinical mastitis. Culture media used were as the following: Sabouraud dextrose agar (SDA) with chloramphenicol; SDA with chloramphenicol & cyclohexamide; and yeast extract-malt agar with chloramphenicol. *Trichophyton verrucosum* was the most dermatophyte zoophilic diagnosticated from the hair samples. From milk samples the yeast *Candida* spp. was the most prevalent pathogen isolated. Samples from cattle with respiratory disorders (n = 27) showed the presence of fungi (18 = 67%) with a great majority being hyalohyphomycetes (15 = 55%). In relationship to positive cultures (49 = 64%) from abortion (77 samples), hyalohyphomycetes (n = 37) were the most isolated fungi, comprising 75.5% of the total isolates, with the genus *Aspergillus* spp. (n = 19; 10 *A. fumigatus*) being the most prevalent within this group; yeasts (7 = 14%) were the 2nd type of fungi cultured from abortion specimens. Also, some dairy and beef cattle feed samples were analyzed for fungal contamination showing various fungal species: rice straw (*Fusarium* sp., *Mucor* sp. and *Aspergillus flavus*); sorghum silage (*Candida albicans*); alfalfa (*A. flavus*, *A. niger* and *Rhizopus* sp.); barley (*A. clavatus*) and feed (*A. clavatus*).
***Discussion*:** The results of fungi isolated from several bovine organs over a period of 38 years are intended to emphasize the need to routinely investigate a possible fungal etiology in various clinical conditions, at least as a differential diagnosis. Mycoses affecting ruminants are usually diagnosed after the animal's death and occur after fungal propagules invade via the airborne, digestive, or intramuscular routes for subsequent hematogenous or lymphatic dissemination to various organs. Due to the fact that the fungi isolated in the present study are ubiquitous, complementary tests, especially histopathological analysis, are often necessary to ascertain with certainty that it is a mycotic condition. Knowledge of the diseases affecting cattle in Brazil, whether caused by bacteria, viruses, fungi, or other etiologies, is very important for decision-making aimed at reducing their occurrence and minimizing the resulting economic losses. The world literature cites parasitic and bacterial diseases, as well as management factors, as the most common causes of losses due to carcass condemnation. Fungi are usually more associated with meat alteration and contamination during refrigerated storage. The fungi, whether filamentous or yeasts, described in the present manuscript are recognized worldwide as being associated with the occurrence of various clinical conditions in several animal species, as well as in humans.

Keywords: mycoses, ruminants, abortion, pneumonia, carcass condemnation, filamentous fungi, yeasts.

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INTRODUCTION

Comparative retrospective studies about occurrence of various diseases diagnosed in ruminants and the respective causes of morbidity and mortality, although scarce in quantity, have been carried out in some regions of Brazil [11,14,15,23].

Mycoses can be acquired through contact with: fungal propagules dispersed in the environment; zoophilic fungi that are maintained in some preferential hosts and which can eventually be transmitted to humans; in addition, many mycoses are endemic in certain regions of the world [6,12,30,32]. Concerning mycoses characterized as opportunistic, the clinical presentations are highly varied. Infections may occur in localized or disseminated (almost always fatal) form, including hyalohyphomycoses (e.g., aspergillosis), mucormycoses, yeast infections (e.g., candidosis) and, increasingly diagnosed, phaeohyphomycoses [32,34].

Fungal diseases in cattle and buffalo have a worldwide distribution and can cause considerable economic losses for livestock farming due to decreased productivity resulting from several factors, which include direct infections, abortions, respiratory diseases, secondary complications such as reduced growth and reproduction, weight loss, and decreased milk production, in addition to treatment costs and even mortality [2,11,12,14,21,30,32].

Besides that, certain mycoses can cause additional losses due to the partial or total condemnation of carcasses, edible offal or by-products [5,12], or by affecting quality and productivity of the milk [8,22,24,26,30,38], affecting the processing and commercialization of meat, milk and their by-products. It is also important to emphasize that the production of mycotoxins by a varied range of fungal species represents an important risk factor for both animal and human health [3,12,28,30-32].

The purpose of the present manuscript is to describe retrospective data on filamentous fungi and yeasts isolated from various organs of cattle with suspected clinical conditions, particularly those related to abortions [Figures 1 & 2] and pneumonias. In addition to these samples, aliquots of milk from cows and buffaloes with suspected subclinical mastitis were also analyzed at the Veterinary Mycology Sector, Department of Veterinary Clinical Pathology, School of Veterinary Medicine (FaVet) of the Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil, during the period from 1986 to 2023.

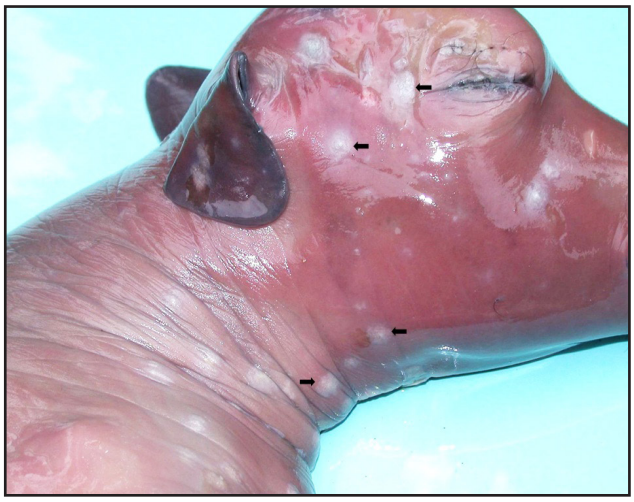

Figure 1. Aborted bovine fetus caused by *Aspergillus fumigatus* showing whitish patches (arrows) on the skin. [Sector of Veterinary Pathology - FaVet - UFRGS].

Figure 2. Aborted bovine fetus caused by *Geotrichum candidum* presenting thickened and wrinkled skin bearing numerous plaques. [Sector of Veterinary Pathology]. [Source: Antoniassi *et al*. 2013. *Journal of Veterinary Diagnostic Investigation*. 25(6): 795-797. DOI: 10.1177/1040638713508284]

MATERIALS AND METHODS

Sampling and analysis period

A total of 232 samples from various bovine organs with different clinical suspicions were processed at the Mycology Sector of the Faculty of Veterinary Medicine (FaVet) of the Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil, over a 38-year period (1986-2023).

The samples received originated from the following systems: integumentary (84) [Figure 3], respiratory (27), reproductive (41), and digestive (36). In addition, 44 aliquots of milk from cows (32) and buffaloes (12) with suspected subclinical mastitis were cultured.

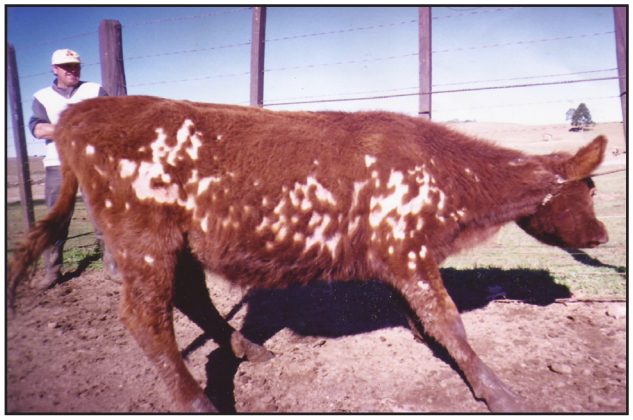

Figure 3. Dermatophytosis due to *Trichophyton verrucosum* during an outbreak in a farm affecting 20 steers. Typical circular and confluent lesions with irregular areas of alopecia are visible spread all over the body. [Sector of Veterinary Mycology - Favet - UFRGS].

Most of the samples (organ fragments and various tissue types) were obtained from the Veterinary Pathology Sector (SPV) of FaVet-UFRGS, and a smaller portion (milk samples) was submitted directly by independent veterinarians.

Processing of integumentary system samples

Hair samples were analyzed by direct examination with 20% KOH to visualize chains of arthroconidia (ectothrix hair invasion) [Figure 4]. Culturing was performed on Sabouraud Dextrose Agar (SDA) containing chloramphenicol and cycloheximide[1] at 27°C and maintained for up to 21 days. Subcultures were performed when necessary.

Processing of respiratory, reproductive, and digestive system samples

Fragments of tissues (lungs, placenta, cotyledons, bovine fetus, esophagus, omasum, abomasum, jejunum, and liver) selected after *post mortem* examination were cultured on SDA[1] and Malt Extract Agar[2]. After 7 days of incubation (37-40°C), colonies of hyaline and dematiaceous hyphomycetes were subcultured on Czapek-Dox Agar[3], while isolates of mucormycetes on SDA[1] for subsequent final macro and microscopic identification. The selected fungal colonies were preserved in saline solution and stored at 4°C.

Processing of milk samples

Approximately 10 mL of milk were aseptically collected in sterile flasks and kept under refrigeration until inoculation onto culture media in the laboratory.

For the isolation of filamentous fungi and yeasts, serial decimal dilutions were prepared from 1 mL of milk diluted in 9 mL of sterile distilled water. Aliquots of 0.1 mL were collected and inoculated in triplicate. Fungal isolation was performed on SDA[1] and Malt Extract Agar[2], incubated at 25°C and 37°C for 5-7 days.

Physiological tests, blastoconidia microscopy, and observation of colony macroscopic characteristics (color and texture) were performed for species identification [Figure 5]. Morphologically, spherical to oval yeast cells were observed. Germ tube formation and chlamydoconidia production on potato agar at 25°C (after 48-72 h of incubation) were evaluated to assist in the identification of *Candida albicans* [24] [Figure 6].

Food samples

Additionally, some feed samples (forage and concentrates for dairy and beef cattle) were cultured on SDA[1] and Malt Extract Agar[2] for the detection of potentially mycotoxin-producing filamentous fungi.

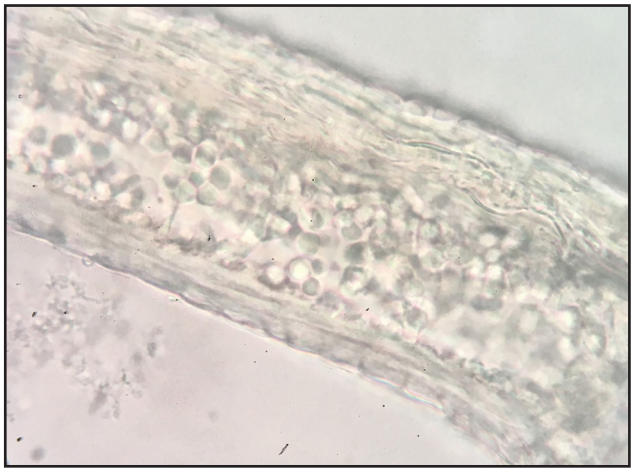

Figure 4. Direct microscopic examination of hair with KOH 20%. Infected hair with hyaline hyphae and chains of arthroconidia (ectothrix invasion) in a heifer with ringworm due to *Trichophyton verrucosum*. [Sector of Veterinary Mycology].

Figure 5. Growth of *Candida albicans* colonies on Sabouraud Dextrose Agar medium at 37°C. [Sector of Veterinary Mycology].

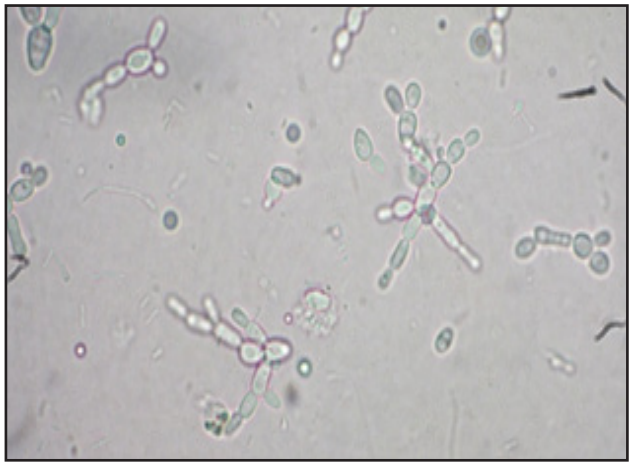

Figure 6. Microscopic features of *Candida albicans*. Capacity to form germ tubes and pseudohyphae when in serum at 37°C. [Sector of Veterinary Mycology].

RESULTS

Among the 232 cultured samples, 117 (50%) were negative and 106 (46%) were positive for the presence of filamentous fungi [dermatophytes, hyaline hyphomycetes (various species), dematiaceous hyphomycetes, and mucormycetes] and yeasts.

Other agents diagnosed, in a small percentage (4%), included: *Pythium insidiosum* (n= 4); *Dermatophilus congolensis* (n= 2); *Chorioptes bovis* (n= 4); *Campylobacter foetus* (n= 1); and *Prototheca* sp. (n= 1).

Integumentary system

A total of 30 fungi was diagnosed (36% = 30/84): 28 dermatophytes [27 *Trichophyton verrucosum* (zoophilic species) and 1 *Nannizzia gypsea* (geophilic species)] and 2 unidentified hyaline hyphomycetes. In addition to fungi, 8 other etiological agents were recorded [oomycetes (4), bacteria (2), and mites (2)] (Table 1).

Respiratory system

A total of 18 fungi were isolated from lung samples (67% = 18/27), predominantly 15 (83%) hyaline hyphomycetes, mainly of the genera *Penicillium* spp. (8) [Figure 7] and *Aspergillus* spp. (4), especially *A. fumigatus*. In addition, one dematiaceous hyphomycete (*Cladosporium* sp.), one mucormycete (*Mucor* sp.), and one yeast (*Candida* sp.) were cultured. *Prototheca* sp. (alga) was also diagnosed (Table 2).

Reproductive system

A total of 27 fungi (66%) were cultured from samples of various organs obtained from 41 abortion cases. The results showed a high prevalence of hyaline hyphomycetes (21/27 = 78%), mainly of the genera *Aspergillus* (11 isolates, including 5 *A. fumigatus*) [Figure 8A & 8B] and *Penicillium* (6). Other fungi identified included 2 yeasts, 1 dematiaceous hyphomycete, and 1 mucormycete. One bacterium (*Campylobacter foetus*) was also isolated (Table 3).

Digestive system

Only fungi (22 = 61%) were isolated from samples of various organs obtained from 36 abortion cases. Hyaline hyphomycetes were also largely predominant, with 16 diagnoses (72%), including 8 (36%) belonging to the genus *Aspergillus* (including 5 *A. fumigatus*). Other fungi cultured included 3 yeasts, 2 mucormycetes, and 1 dematiaceous hyphomycete (Table 4).

Milk from cows and buffaloes

Only 23% (n = 10) of the 44 cultures revealed the presence of fungi, 9 from cow milk and 1 from buffalo milk. Nine yeasts of the genus *Candida* (including 2 *C. albicans* and 1 *C. tropicalis*) and 1 hyaline hyphomycete (*Geotrichum* sp.) were isolated (Table 5).

Animal feed

Additionally, a few feed samples (n = 14) from dairy and beef cattle showed the presence of various fungal species: feed (4) [*A. clavatus*]; barley (3) [A. clavatus]; rice straw (2) [*Fusarium* sp., *Mucor* sp., and *Aspergillus flavus*]; alfalfa (2) [*A. flavus*, *A. niger*, and *Rhizopus* sp.]; corn (2) [*Aspergillus fumigatus*]; and sorghum silage (1) [*Candida albicans*].

Table 1. Fungi and other microorganisms diagnosed from cutaneous system lesions in bovines during the period of 1986-2023.

Microorganisms	N
Trichophyton verrucosum	27
Pythium insidiosum[1]	4
Unidentified hyalohyphomycetes	2
Dermatophilus congolensis[2]	2
Chorioptes bovis[3]	2
Nannizzia gypsea[4]	1
TOTAL	38

[1]Oomycete (Kingdom Stramenopila) etiological agent of pythiosis. [2]Filamentous bacterium that causes dermatophilosis. [3]Chorioptic mange mite. [4]Current nomenclature of the geophilic dermatophyte *Microsporum gypseum*. Percentages: isolated fungi: 35.7% (30/84) and negative tests: 54.8% (46/84).

Table 2. Fungi isolated from the lungs of bovines with clinical signs of respiratory disease during the period of 1997-2022.

Fungi	N
Penicillium spp.	8
Aspergillus fumigatus	3
A. flavus	1
Trichoderma sp.	1
Unidentified hyalohyphomycete	1
Geotrichum sp.	1
Cladosporium sp.	1
Mucor sp.	1
Candida sp.	1
TOTAL	18

Obs.: 1 *Prototheca* sp. (alga) was also isolated from the lung.

Table 3. Fungi isolated from diverses organs* of bovines in cases of abortion during the period of 1998-2018.

Fungi	N
Penicillium spp.	6
Aspergillus fumigatus	5
Aspergillus spp.	3
A. flavus	2
A. niger	1
Unidentified yeasts	2
Geotrichum spp.	2
Fusarium sp.	1
Unidentified hyalohyphomycete	1
Cladosporium sp.	1
Mucor sp.	1
Candida albicans	1
Rhodotorula mucilaginosa	1
TOTAL	27

*Placenta; cotyledons; bovine fetus and lungs. Also, 1 *Campylobacter foetus* (bacterium) was diagnosed. Percentages: fungi isolated: 65.8% (27/41) and negative tests: 34.2% (14/41)

Table 4. Fungi isolated from the digestive system and accessory organs* of bovines in cases of abortion during the period of 1998-2018.

Fungi	N
Aspergillus fumigatus	5
Penicillium spp.	3
Aspergillus spp.	2
Unidentified hyalohyphomycetes	2
Geotrichum candidum	2
Aspergillus flavus	1
Unidentified yeast	1
Fusarium sp.	1
Cladosporium sp.	1
Mucor sp.	1
Rhizopus sp.	1
Candida albicans	1
Rhodotorula mucilaginosa	1
TOTAL	22

*Esophagus; abomasum; omasum; jejunum; mesenteric mass; liver and hepatic nodules. Percentages: isolated fungi: 61.1% (22/36) and negative exams: 38.9% (14/36).

Table 5. Fungi isolated from the milk* of cows and buffaloes in cases of suspected subclinical mastitis during the period of 2009-2016.

Fungi	N
Cows	
Candida spp.	5
Candida albicans	2
Candida tropicalis	1
Geotrichum sp.	1
Bufalloes	
Candida sp.	1
TOTAL	10

*Total general of milk exams: 44 [cows (32) and buffaloes (12)] with 10 isolates (22.7%) and 34 negative cultures (77.3%).

Figure 7. Microscopic characteristics of *Penicillium* sp. (arrow) cultured on Malt Extract Agar (MEA) at 37°C. [Sector of Veterinary Mycology].

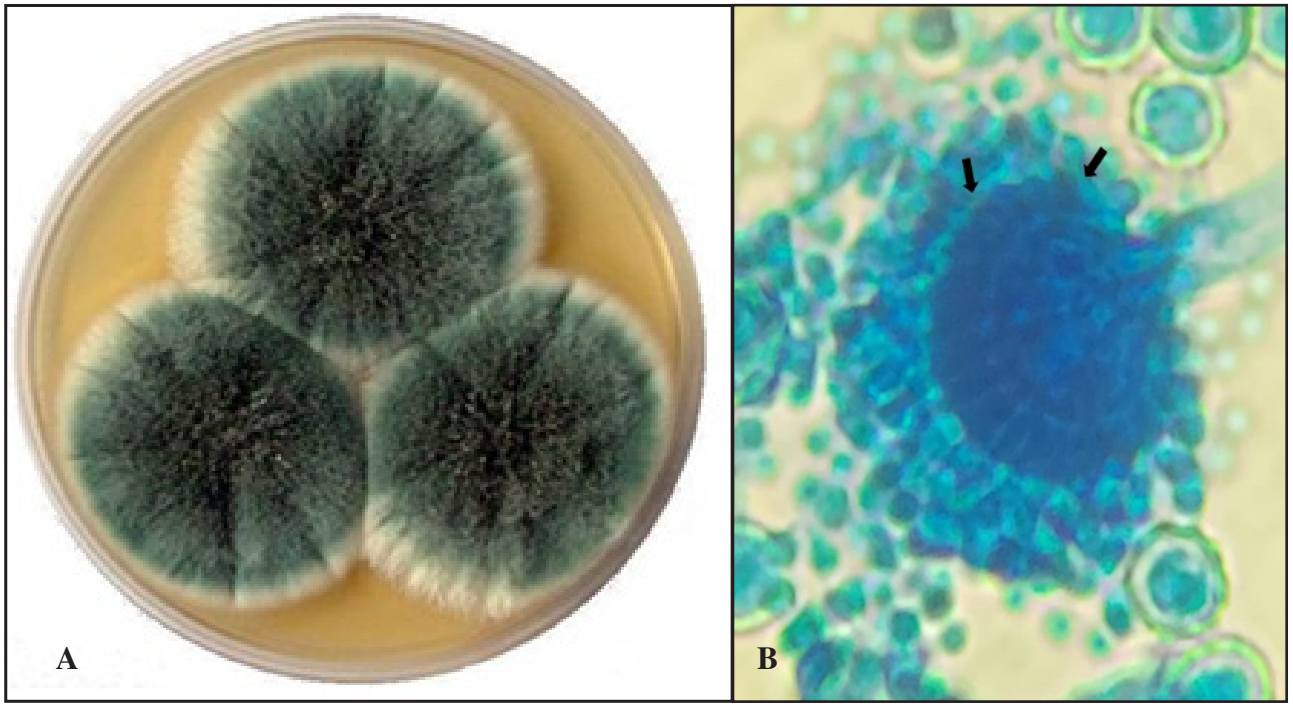

Figure 8. Macroscopic (A) and microscopic (B) characteristics of *Aspergillus fumigatus* (arrows) cultured on Malt Extract Agar (MEA) at 37°C. [Sector of Veterinary Mycology].

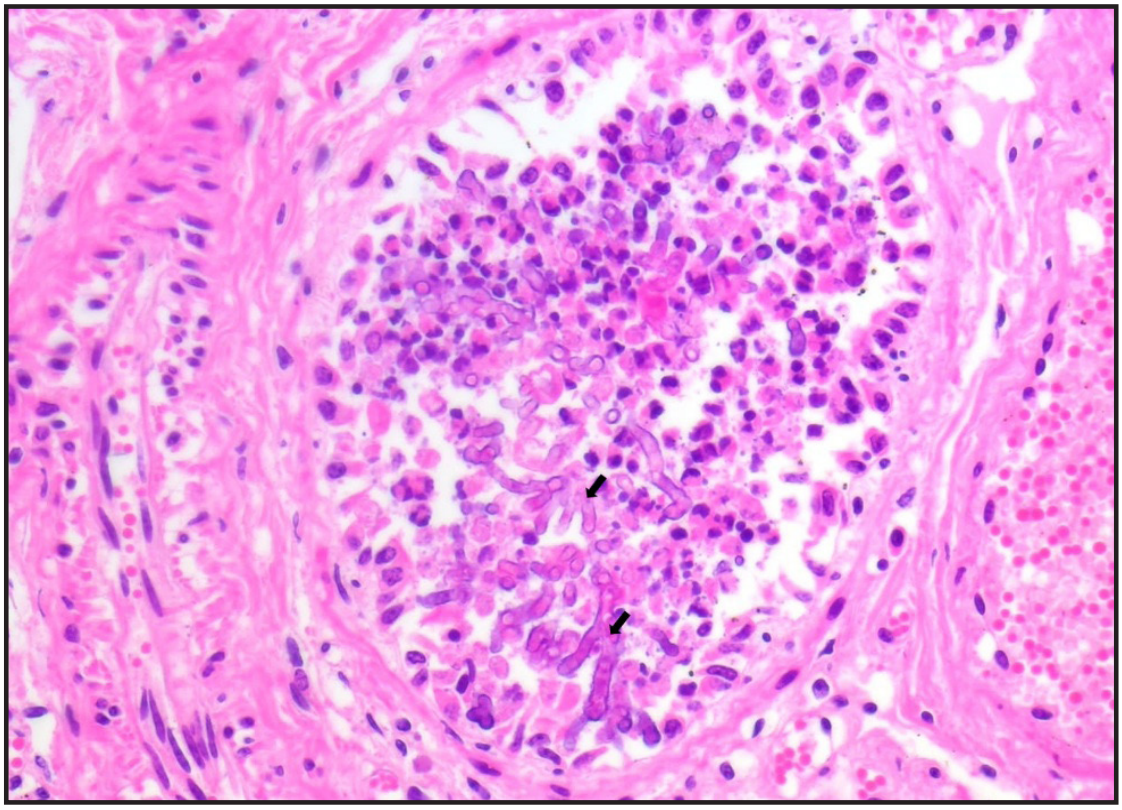

Figure 9. Fungal bronchopneumonia in a calf. Bronchiole with necrotic debris and presence of septate hyaline and branched hyphae microscopic highly suggestive (arrows) of the *Aspergillus* spp. [HE; 40x]. [Sector of Veterinary Pathology]. *Aspergillus fumigatus* was isolated in in pure culture. [Sector of Veterinary Mycology].

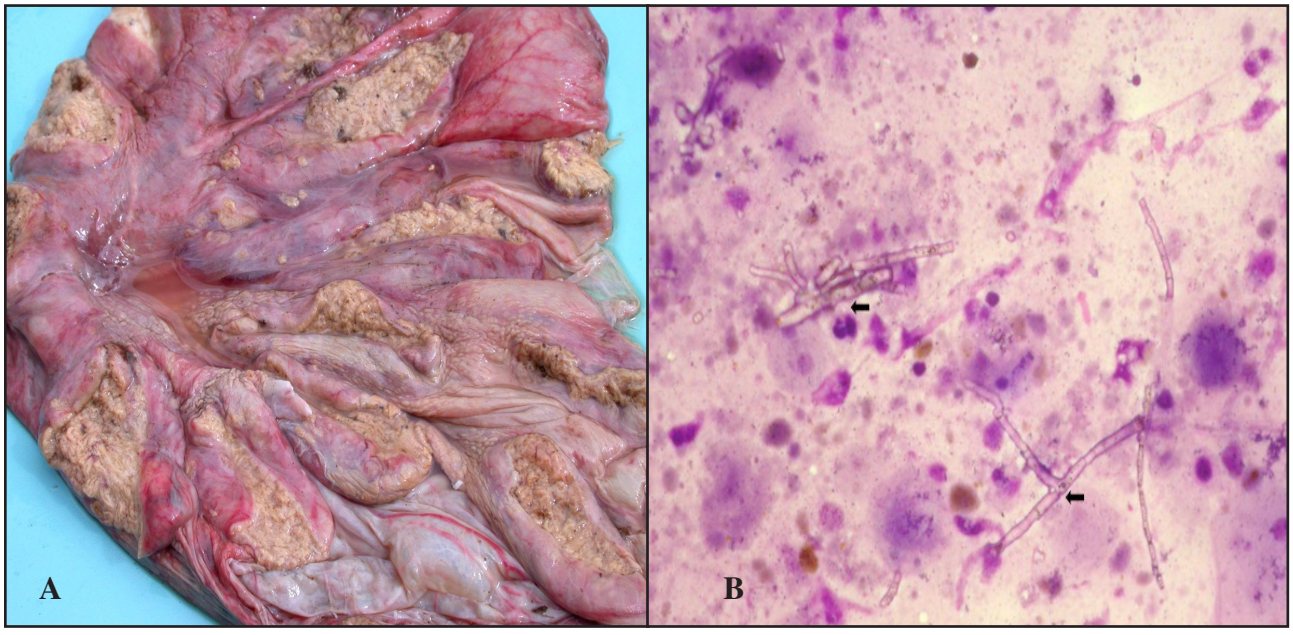

Figure 10. Examination of the placenta (A) showing necrotic, whitish cotyledons containing septate hyaline fungal hyphae (arrows), as revealed by lesion smear analysis (B) stained with Panoptic fast staining technique [40x]. [Sector of Veterinary Pathology].

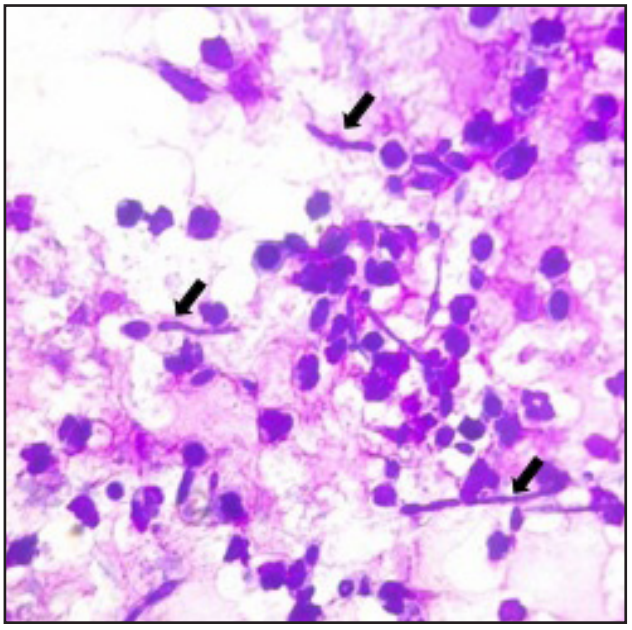

Figure 11. Placental cytology with the presence of blastoconidia and pseudohyphae (arrows). [Sector of Veterinary Pathology]. *Candida albicans* was isolated in pure culture. [Sector of Veterinary Mycology].

DISCUSSION

The retrospective results over a period of 38 years of the fungi isolated from various bovine organs at the Sector of Veterinary Mycology of FaVet - UFRGS aim to emphasize the need to routinely investigate a possible fungal etiology in different clinical conditions, at least as a differential diagnosis. The purpose of this manuscript is not to provide an extensive literature review, but rather to highlight some pioneering studies conducted in Brazil and in other parts of the world, as well as more recent works, in order to compare them with the data presented here [11,12,15,23,30,32].

Mycoses affecting ruminants are usually diagnosed after the animal's death and occur when conidia invade through the respiratory [Figure 9], digestive, or intramuscular routes, subsequently spreading via the bloodstream or lymphatic system to various organs. Because the fungi isolated in the present study are ubiquitous, diagnosing fungal disease often requires complementary techniques, particularly particularly cytological and histopathological analysis [Figures 10 & 11] and, when possible, the use of molecular tools [12,30,32,34,37].

In mycotic abortion in ruminants, the identification of hyphae (septate or non-septate) in the histopathology of the placenta or fetal skin is essential for diagnosis. Fungal culture from the fetal abomasal contents can also be useful; however, it is important to note that culture of the placenta alone cannot be considered conclusive due to the possibility of environmental contamination [2,16,19,21].

Among the fungal pathogens with worldwide distribution that are associated with diseases affecting various systems and organs in cattle, *Trichophyton verrucosum*, *Aspergillus fumigatus*, and *Candida albicans* are among the most significant [4,12,30,32,33,39]. These species were also frequently isolated in the case series presented in this study (Tabelas 1, 2 , 3 & 4).

Dermatophytosis

Trichophyton verrucosum is considered the principal etiological agent of bovine dermatophytosis worldwide, although it can also infect other ruminants, as well as various animal species and humans [6,12,17,30,39]. In Brazil, it is likewise the most commonly diagnosed dermatophyte in cattle [37].

Isolates from respiratory diseases

A study on cattle with bovine respiratory disease (BRD) reported a higher occurrence of fungi and bacteria in the nasal cavity or nasopharynx compared with healthy animals [4]. The same authors suggested the need for studies that clarify how fungi and bacteria interact in the bovine respiratory tract in order to determine whether fungi play a role in the development of BRD and to identify any indicators that may assist in diagnosing the disease. Quantifying pathogens present in the nasal cavity or nasopharynx may help distinguish sick cattle from healthy ones [4].

Pulmonary mycosis is one of the main causes of death in many cattle herds, especially in immunocompromised animals. In a study conducted in Nigeria, among 34 isolates from 138 lungs, *Aspergillus* spp., ubiquitous in the environment, showed the highest isolation frequency (44.92%), followed by *Penicillium* spp. (11.76%) [25].

Aspergillosis, predominantly caused by *Aspergillus fumigatus*, is diagnosed in nearly all domestic animals and birds, as well as in many wildlife species [33,35]. It is considered primarily a pulmonary mycosis that can become generalized; however, it is important to note that tissue tropism varies among affected animals [4,35,40].

Aspergillus spp., which infect both animals and humans, remain a constant public health concern [33].

Isolates from the digestive system

Some studies on mycoses of the bovine gastrointestinal tract (GIT) indicate that the omasum is the main target organ for infections, followed by the rumen and reticulum.

Aspergillosis and mucormycoses were diagnosed in approximately 34.4% of the samples examined, including co-infection cases. In addition, fungi of the order Mucorales have been associated with lymphadenitis in cattle [18]. The literature also reports cases of hematogenous dissemination of *Aspergillus* spp. to the liver, resulting in mycotic hepatitis, as well as involvement of the lungs and kidneys in some animals [20].

Isolates from abortions

Fungal infections can cause placentitis and abortion, events already documented in a wide range of domestic animals [2,40]. Early reports had already drawn attention to the substantial economic losses that may result from mycotic abortions, whose prevalence can reach nearly 25% [2].

A pioneering report of mycotic abortion was described by Theobald Smith in 1920, in which *Mucor rhizopodiformis* was the only microorganism isolated from the chorion of a cow and from the lungs and digestive tract of the fetus [36].

During a 27-year period, Hillman [16] observed wide annual variations in the prevalence of abortions, ranging from 0 to 16.4%. *Aspergillus fumigatus* was the main species identified in bovine mycotic abortion, being isolated in approximately 60% to 75% of diagnosed cases and primarily from placental tissue, which is usually the most affected site [2].

Earlier studies had already warned that mycotic abortion had a worldwide distribution, with prevalence rates ranging between 1% and 24.9% [2,21].

In a study of 6,858 cases of bovine abortion, the prevalence of mycotic abortion was 6.8%, with *A. fumigatus* isolated in 62% of these cases [21].

Mycotic abortion is the most common clinical manifestation of aspergillosis in cattle [2,9,11,21,40].

In Brazil, the analysis of lung, liver, and placental samples from fetuses in bovine abortion cases reported a prevalence of 3.4% for *Aspergillus* spp., mainly the species *A. fumigatus* and *A. niger*. Various fetal gross and microscopic lesions were described, including fibrinonecrotic hepatitis, diffuse interstitial pneumonia, and severe placentitis [9]. Other species, such as *A. nidulans* and *A. luchuensis*, have also been identified as etiologic agents [27]. In the present study, *A. fumigatus* was identified in 10 cases out of a total of 19 *Aspergillus* isolates.

Due to the angioinvasion frequently observed in infections caused by species of the order Mucorales, hematogenous dissemination to multiple organs occurs regularly. In pregnant cows, mucormycetes may infect the placenta; however, the hyalohyphomycete *Aspergillus fumigatus* is considered the fungus most frequently isolated from cases of placentitis and abortion in cattle [19,21].

Knudtson & Kirkbride [21] conducted a retrospective study spanning nearly a decade on fungi associated with bovine abortion. Mycotic infection was diagnosed in 466 (6.8%) of the 6,858 cases. *Aspergillus* spp. were associated with approximately 5% (343) of all abortions examined. *Aspergillus fumigatus* was the most frequently isolated species (62%), followed by *A. terreus* (6.7%). Mucormycetes accounted for 21% of the fungal isolates, and yeasts for 2%. Other *Aspergillus* species identified included *A. flavus* (12.5%) and *A. nidulans* (3.0%). Mucormycetes (including *Absidia*, *Mortierella*, *Rhizomucor*, and *Rhizopus*) were isolated in 21% of cases, while yeasts (*Candida*, *Torulopsis*) were detected in 2%. Additionally, in 2% of the mycotic abortions, uncommon agents such as the phaeohyphomycetes *Curvularia geniculata* and *Exophiala jeanselmei* were isolated.

The authors emphasize that mixed infections involving hyalohyphomycetes and mucormycetes occurred in 10% of the mycotic abortions, with both septate and aseptate hyphae observed on the histopathological examination of placental tissue. Overall, in 12% of the cases, the mycological diagnosis was based solely on histopathology findings [21].

Only a small number of cases of phaeohyphomycosis, which are considered opportunistic diseases, have been reported in ruminants in the literature [21,34]. In the present study, only the genus *Cladosporium* was isolated from the samples.

A pioneering study on abortion in cows caused by yeasts found in the environment reported the isolation of *C. parapsilosis*, *C. tropicalis*, and *C.*

guilliermondii [13]. *C. albicans* is a normal inhabitant of the nasopharynx, gastrointestinal tract, and external genitalia of many animal species and is considered an opportunistic agent [13,32].

Isolates from subclinical mastitis

Mastitis is considered one of the main causes of economic losses in the global dairy industry. In Brazil, Acosta *et al*. [1], compiling a decade of data on the prevalence of subclinical mastitis in ruminants, reported high percentages: 48.64% in cows, 30.7% in goats, 31.45% in sheep, and 42.2% in buffaloes, with *Staphylococcus* spp. as the predominant pathogen.

Although the etiology is mostly bacterial - especially *Staphylococcus* spp. and *Streptococcus* spp. - the literature has recently documented a growing number of fungal isolates, either during outbreak investigations or in surveys assessing etiological agents in ruminants across different geographical regions, as shown in studies conducted in Brazil [1,7,8,10,23,24,31,38] and abroad [22,26].

Among the reports of yeasts causing mastitis, the genus *Candida* has been isolated in up to 37.9% of subclinical mastitis cases [38]. Mastitis caused by *Candida* spp. is usually considered a sequela of previous antimicrobial therapy against bacteria [7,22].

In the small sample described in the present study, *Candida* spp. was also the most frequently isolated genus. In Brazil, some studies have highlighted the occurrence of *C. albicans* in cases of mastitis: 8.9% [31], 28.1% [8], and 33.34% [7].

It is important to emphasize that all fungi diagnosed in the samples cultured at the Sector of Veterinary Mycology of the FaVet-UFRGS can, due to their ubiquitous nature, contaminate cattle at various stages of their development. Likewise, fungal contamination may occur at all stages of carcass handling and processing in commercial slaughterhouses [3].

CONCLUSION

Knowledge of the diseases that affect cattle in Brazil - whether caused by bacteria, viruses, fungi, or other etiologies - is crucial for decision-making aimed at reducing their occurrence and minimizing the resulting economic losses.

The literature cites parasitic and bacterial diseases, as well as management-related factors (such as emaciation and bruising), as the most common causes of carcass condemnation and related losses. Fungi are generally more associated with spoilage and contamination of meat during refrigerated storage.

Although fungi, whether filamentous or yeasts, do not represent a major cause of economic loss in cattle slaughterhouses, it is important to note that the etiological agents described in this manuscript are widely recognized as being associated with various clinical conditions in multiple animal species, as well as in humans.

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