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Veterinary Mycology: Fungal Infections in Livestock and Companion Animals

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Abstract

Fungal infections represent a significant yet often underestimated challenge in veterinary medicine, affecting both livestock and companion animals. Veterinary mycology encompasses a diverse group of pathogens, including yeasts, molds, dimorphic fungi, and dermatophytes, that can cause localized or systemic diseases with substantial health, economic, and zoonotic implications. In livestock species, such as cattle, sheep, goats, poultry, pigs, horses, and camels, fungal infections manifest as dermatophytosis, mycotic mastitis, aspergillosis, keratomycosis, and candidiasis, leading to reduced productivity, compromised animal welfare, and increased treatment costs. Companion animals, particularly dogs and cats, are equally susceptible to fungal diseases, including cryptococcosis, sporotrichosis, blastomycosis, and ringworm, some of which carry zoonotic potential and pose risks to veterinarians, farmers, and pet owners. The pathogenesis of fungal infections is complex, involving host immune status, fungal virulence mechanisms such as spore formation and biofilm development, and environmental factors. Accurate diagnosis is essential and relies on a combination of classical techniques – microscopy, culture, serology – and modern molecular tools such as polymerase chain reaction and sequencing. Treatment options include azoles, polyenes, and echinocandins; however, antifungal resistance, drug toxicity, and cost limitations present persistent challenges. Preventive strategies emphasize biosecurity, hygiene, and emerging research into vaccines and immunotherapies. From a public health perspective, veterinary fungal diseases align closely with the One Health concept, highlighting interconnected risks to humans, animals, and the environment. With climate change, globalization, and antimicrobial resistance influencing fungal epidemiology, the importance of surveillance, early diagnosis, and innovative therapeutics is increasing. This review summarizes current knowledge on fungal infections in livestock and companion animals, explores diagnostic and therapeutic advancements, and highlights future directions for integrated control strategies to safeguard animal health, food security, and public health.

Keywords: Veterinary mycology, fungal infections, livestock diseases, companion animals, dermatophytosis

INTRODUCTION

Fungi constitute an important group of pathogens in veterinary medicine, responsible for a wide range of infections in livestock and companion animals. While bacterial and viral diseases have traditionally dominated veterinary research, fungal infections are increasingly being recognized for their clinical, economic, and zoonotic significance. These pathogens include yeasts, molds, dimorphic fungi, and dermatophytes, which can cause conditions ranging from superficial skin infections to severe systemic mycoses. Their impact extends beyond animal health, affecting productivity, food safety, animal welfare, and public health under the One Health framework. In livestock, fungal infections, such as mycotic mastitis in cattle, aspergillosis in poultry, dermatophytosis in ruminants, and

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candidiasis in pigs, are associated with significant economic losses through decreased production efficiency, reproductive failure, and increased treatment costs [1]. Companion animals, particularly dogs and cats, are susceptible to systemic mycoses, including cryptococcosis, blastomycosis, and sporotrichosis, in addition to contagious dermatophytosis, which is a common zoonotic concern. Occupational exposure further places farmers, veterinarians, and pet owners at risk of transmission. Despite their importance, fungal infections remain underdiagnosed and undertreated due to limitations in conventional diagnostic methods, high costs of antifungal therapy, emerging resistance, and lack of effective vaccines. Recent advances in molecular diagnostics, sequencing technologies, and immunological studies are contributing to improved detection and understanding of host–pathogen interactions. As climate change, antimicrobial resistance, and globalization reshape fungal epidemiology, veterinary mycology is becoming increasingly relevant for integrated animal and human health. This review provides an overview of fungal infections in livestock and companion animals, highlighting their etiology, pathogenesis, diagnostic approaches, therapeutic challenges, and future research directions [2].

CLASSIFICATION OF VETERINARY FUNGI

Veterinary fungi can be broadly classified into four major groups based on their morphology, growth characteristics, and clinical manifestations: yeasts, molds, dimorphic fungi, and dermatophytes. Each group comprises important pathogens with distinct biological properties and veterinary relevance.

Yeasts

Yeasts are unicellular fungi that reproduce primarily by budding. Among them, *Candida spp.* are the most significant in veterinary medicine. *Candida albicans* and related species are opportunistic pathogens causing mucocutaneous infections and systemic candidiasis in livestock and companion animals, particularly under conditions of immunosuppression, prolonged antibiotic use, or poor hygiene. In cattle, *Candida* can be implicated in mycotic mastitis, while in poultry and pigs, candidiasis commonly affects the gastrointestinal tract [3].

Molds

Molds are filamentous fungi characterized by the formation of hyphae and spore production. *Aspergillus spp.*, especially *Aspergillus fumigatus*, is a prominent veterinary pathogen. They are responsible for respiratory infections such as aspergillosis in birds, mycotic abortion in cattle, and guttural pouch mycosis in horses. Mold infections are often associated with environmental exposure, particularly in damp feed and litter, making them a major concern in intensive farming systems [3].

Dimorphic Fungi

Dimorphic fungi can exist as molds in the environment and as yeasts or yeast-like forms within host tissues. They include important zoonotic pathogens such as *Histoplasma capsulatum* and *Blastomyces dermatitidis*. In dogs and cats, these fungi cause systemic mycoses, often presenting as chronic respiratory, cutaneous, or disseminated disease. Their geographic distribution is often restricted to specific endemic regions, but increasing reports suggest wider occurrence due to climate and ecological changes [3].

Dermatophytes

Dermatophytes are keratinophilic fungi that invade the skin, hair, and nails. The main veterinary pathogens include *Microsporum* and *Trichophyton* species. Dermatophytosis (ringworm) is highly contagious and affects a wide range of hosts, including cattle, sheep, goats, horses, dogs, and cats. In addition to causing economic losses in livestock due to hide damage and reduced productivity, dermatophytes are of zoonotic importance, frequently transmitted from animals to humans, especially children and farm workers [3].

FUNGAL INFECTIONS IN LIVESTOCK

Fungal diseases in livestock have considerable economic and welfare implications, as they can reduce productivity, impair reproductive efficiency, and increase treatment and management costs. The

spectrum of infections varies with species, management practices, and environmental conditions. Among the most common fungal pathogens in livestock are *Candida*, *Aspergillus*, *Fusarium*, and dermatophytes such as *Trichophyton* and *Microsporum* [4].

Cattle

In cattle, mycotic mastitis is one of the most important fungal infections, frequently caused by *Candida spp.*, *Aspergillus spp.*, and *Cryptococcus spp.* It typically occurs as a secondary infection following prolonged antibiotic or corticosteroid treatment. Additionally, mycotic abortions, often due to *A. fumigatus*, pose significant reproductive losses. Dermatophytosis caused by *Trichophyton verrucosum* is another major concern, particularly in calves, leading to skin lesions and decreased hide value [4].

Sheep and Goats

Sheep and goats are susceptible to dermatophytosis caused by *Trichophyton* and *Microsporum* species, which spreads rapidly in flocks under intensive housing. Mycotic mastitis is also reported, though less common than in cattle. In addition, systemic mycoses, although relatively rare, can emerge under stress or immunocompromised states [4].

Pigs

Fungal infections in pigs are less common but can involve candidiasis of the oral cavity and gastrointestinal tract, particularly in young piglets. Mycotoxicoses, resulting from ingestion of contaminated feed with *Aspergillus*, *Fusarium*, or *Penicillium* toxins, are of greater concern. These toxins impair immunity, reduce growth, and cause reproductive failure, indirectly predisposing animals to other infections.

Poultry

In poultry, aspergillosis is a major fungal disease caused predominantly by *A. fumigatus*. It is associated with contaminated hatcheries, feed, and litter, leading to respiratory distress, high chick mortality, and economic losses in commercial flocks. Candidiasis, primarily due to *C. albicans*, can affect the crop and intestines, especially in immunocompromised or malnourished birds.

Horses and Camels

In horses, fungal infections include dermatophytosis, keratomycosis (corneal fungal infections often linked to *Aspergillus* or *Fusarium*), and guttural pouch mycosis, a serious condition involving fungal colonization of the guttural pouch leading to hemorrhage and neurological signs. In camels, dermatophytosis and systemic infections, such as aspergillosis, are reported, while recent evidence highlights their role as potential reservoirs for emerging pathogens such as *Candida* and *Aspergillus*.

FUNGAL INFECTIONS IN COMPANION ANIMALS

Companion animals, particularly dogs and cats, are prone to a variety of fungal infections ranging from superficial skin diseases to life-threatening systemic mycoses. These infections are of special concern because of their zoonotic potential and the close contact pets share with humans. Factors, such as immunosuppression, poor nutrition, environmental exposure, and prolonged antimicrobial, use increase susceptibility to fungal diseases in companion animals [5].

Dogs

In dogs, dermatophytosis (ringworm) is a common fungal disease caused by *Microsporum canis*, *Microsporum gypseum*, and *Trichophyton mentagrophytes*. It presents as alopecia, scaling, and circular lesions and can spread rapidly among pets and humans. Systemic fungal infections in dogs include blastomycosis (*B. dermatitidis*), histoplasmosis (*H. capsulatum*), and **coccidioidomycosis* (*Coccidioides immitis*), depending on geographic distribution. Dogs are also highly susceptible to aspergillosis, particularly sinonasal aspergillosis caused by *A. fumigatus*, which manifests as nasal discharge, sneezing, and turbinate destruction [5].

Cats

Cats are frequently affected by cryptococcosis, caused by *Cryptococcus neoformans* and *Cryptococcus gattii*. This infection commonly involves the nasal cavity and central nervous system, presenting with sneezing, nasal deformity, or neurological signs. Sporotrichosis, caused by *Sporothrix schenckii*, is another important feline mycosis, often transmitted through scratches or bites and notable for its zoonotic potential, particularly in endemic regions of Latin America. Like dogs, cats may also develop dermatophytosis, with *M. canis* being the leading cause, especially in multi-cat environments such as shelters [5].

Zoonotic Concerns

Fungal infections in companion animals pose a substantial zoonotic risk. Dermatophytosis and sporotrichosis are most transmitted to humans, especially children, the elderly, and immunocompromised individuals. Veterinary personnel, breeders, and pet owners are at a higher occupational risk of exposure. With the rise of antifungal resistance and increasing pet ownership worldwide, fungal zoonoses remain a significant One Health concern requiring better surveillance, education, and integrated control measures.

PATHOGENESIS AND HOST–PATHOGEN INTERACTIONS

The development of fungal infections in animals depends on a complex interplay between fungal virulence factors, host susceptibility, and environmental conditions. While many fungi exist as harmless saprophytes in soil, feed, and bedding, they can become opportunistic pathogens under favorable circumstances such as immunosuppression, stress, or prolonged antimicrobial use [6].

Routes of Infection

Fungi typically invade the host through the respiratory tract, skin, or alimentary tract. Inhalation of spores is the primary route for systemic mycoses such as aspergillosis, histoplasmosis, and blastomycosis. Cutaneous fungi, like dermatophytes, invade keratinized tissues (skin, hair, and claws), while yeasts, such as *Candida spp.*, exploit mucosal surfaces under conditions of dysbiosis or reduced host defenses.

Fungal Virulence Factors

Pathogenic fungi possess diverse mechanisms to establish infection. Spore production enables environmental persistence and airborne transmission. Adhesion molecules facilitate attachment to host tissues, while enzymes, such as keratinases, proteases, and lipases, help invade epithelial barriers. Biofilm formation, particularly in *Candida* and *Aspergillus*, provides resistance against host immunity and antifungal drugs. Some fungi also produce mycotoxins that impair immune responses and exacerbate disease severity.

Host Immune Response

Host defense against fungal infections involves both innate and adaptive immunity. Innate mechanisms include skin and mucosal barriers, phagocytosis by neutrophils and macrophages, and recognition of fungal cell wall components (β-glucans, mannans) via pattern recognition receptors such as toll-like receptors and dectin-1. Adaptive immunity is mediated by T-cell responses, particularly Th1 and Th17 pathways, which enhance antifungal activity. Conversely, Th2 responses may promote chronicity in dermatophytosis and allergic aspergillosis. Antibody responses, though less protective, can aid in opsonization and diagnostics [6].

Factors Influencing Susceptibility

Several host-related factors influence disease outcome. Young or aged animals, immunocompromised individuals, and those receiving prolonged antibiotics or corticosteroids are more susceptible to opportunistic mycoses. Environmental conditions, such as humidity, poor housing, and contaminated feed, also predispose livestock and pets to fungal infections.

DIAGNOSIS OF FUNGAL INFECTIONS

Accurate and timely diagnosis of fungal infections in animals is essential for effective treatment, prevention of disease spread, and reduction of economic losses. However, diagnosis can be challenging because clinical signs are often nonspecific and overlap with those caused by bacterial, viral, or parasitic pathogens. A combination of clinical examination, laboratory techniques, and advanced molecular methods is, therefore, required to establish a definitive diagnosis [7].

Clinical Examination

Superficial mycoses, such as dermatophytosis, typically present with circular alopecia, crusting, and scaling, while systemic infections may cause respiratory signs, neurological deficits, or generalized illness. A thorough case history, including environmental conditions, recent antimicrobial use, and immunosuppressive therapy, can provide important diagnostic clues.

Conventional Laboratory Methods

- *Direct Microscopy:* Wet mount preparations with potassium hydroxide (KOH) or special stains (e.g., lactophenol cotton blue, calcofluor white) allow rapid visualization of fungal elements in skin scrapings, hair, and tissue samples.
- *Culture:* Sabouraud dextrose agar (SDA) remains the gold standard for fungal isolation, permitting species-level identification based on colony morphology and microscopic features. Dermatophyte test media (DTM) are particularly useful in clinical veterinary practice.
- *Histopathology:* Tissue biopsy stained with Periodic acid–Schiff (PAS) or Gomori methenamine silver (GMS) helps visualize hyphae and yeasts in situ, supporting diagnosis of systemic mycoses [7].

Serological and Antigen Detection

Serological assays, such as enzyme-linked immunosorbent assay (ELISA), latex agglutination, and immunodiffusion, are valuable for detecting circulating antigens or antibodies against fungi like *Cryptococcus* and *Histoplasma*. These methods are particularly useful for systemic mycoses where cultures may be difficult or slow.

Molecular Diagnostics

Molecular methods, especially polymerase chain reaction (PCR), real-time PCR, and sequencing, have revolutionized fungal diagnostics by enabling rapid and sensitive detection of pathogens directly from clinical samples. DNA-based identification of *Candida*, *Aspergillus*, and dermatophytes provides higher specificity than conventional culture. More recently, next-generation sequencing (NGS) and metagenomic approaches have been applied to study fungal communities and emerging infections.

Imaging Techniques

In systemic mycoses of dogs, cats, and horses, radiography, ultrasound, and computed tomography (CT) can assist in identifying lesions in the lungs, bones, or sinuses. Although not definitive, these tools complement laboratory findings in establishing the extent of infection.

Treatment and Control of Fungal Infections

Fungal infections in animals pose significant therapeutic challenges due to the limited availability of antifungal drugs in veterinary practice, their potential toxicity, long treatment durations, and the rising problem of antifungal resistance. Management requires a combination of antifungal therapy, supportive care, environmental control, and preventive strategies tailored to the type of infection and the host species [8].

Antifungal Therapy

- *Polyenes: Amphotericin B* is highly effective against systemic mycoses, such as aspergillosis and cryptococcosis, but is limited by nephrotoxicity. Lipid formulations have improved safety but remain costly.

- *Azoles:* Drugs, like *ketoconazole, itraconazole, fluconazole,* and *voriconazole*, are widely used due to good oral bioavailability and broad-spectrum activity. Itraconazole is preferred for dermatophytosis and systemic infections in dogs and cats.
- *Allylamines: Terbinafine* is effective against dermatophytes and yeasts, particularly in small animals.
- *Echinocandins: Caspofungin* and related drugs, though limited in veterinary use, show promise against resistant *Candida* and *Aspergillus* infections.
- *Topical Antifungals:* Miconazole, clotrimazole, and lime sulfur dips are commonly applied for dermatophytosis and localized yeast infections [9].

Antifungal Resistance

Increasing resistance in fungi, such as *C. albicans* and *A. fumigatus*, has been reported in veterinary medicine, driven by inappropriate use of antifungals, environmental azole exposure, and biofilm formation. This trend highlights the need for susceptibility testing and rational drug use.

Supportive and Adjunctive Therapies

Supportive care includes nutritional management, fluid therapy, and treatment of concurrent bacterial infections. Immunomodulators and probiotics have been explored to enhance host resistance, particularly in immunocompromised animals. Surgical debridement may be required for localized infections such as guttural pouch mycosis in horses.

Environmental and Management Control

Preventing reinfection is critical, particularly for dermatophytosis and aspergillosis. Measures include disinfection of housing, proper ventilation, removal of contaminated bedding, and isolation of infected animals. Regular grooming, good nutrition, and minimizing stress improve natural defenses [10].

Vaccination and Future Approaches

Currently, no commercial vaccines are available for most veterinary fungal infections. However, research into DNA vaccines, recombinant proteins, and fungal cell wall components (β-glucans, mannoproteins) shows promise. Advances in immunotherapy, mycobiome modulation, and nanotechnology-based antifungal delivery systems represent exciting future directions for fungal disease control in animals.

PREVENTION AND CONTROL STRATEGIES

Preventing fungal infections in animals is often more practical and cost-effective than treatment, particularly in large livestock populations where therapeutic options are limited and recurrence is common. Effective prevention requires a multifaceted approach involving good husbandry, biosecurity, hygiene, and regular health monitoring.

Biosecurity and Farm Management

Maintaining strict biosecurity protocols reduces the introduction and spread of fungal pathogens. New or sick animals should be quarantined before introduction into herds. Regular cleaning and disinfection of animal housing, equipment, and transport vehicles minimizes environmental contamination [11, 12].

Environmental Hygiene

Fungi thrive in warm, humid, and poorly ventilated environments. Preventive measures include:

- Ensuring adequate ventilation in animal housing.
- Removing damp or moldy feed, straw, and bedding.
- Regular disinfection using antifungal agents where outbreaks have occurred.
- Safe disposal of contaminated materials such as hair, skin scrapings, or bedding from infected animals.

Nutrition and Stress Management

Balanced nutrition strengthens the immune system and enhances resistance to opportunistic infections. Stressors, such as overcrowding, transportation, and abrupt diet changes, should be minimized, as they compromise immune defenses and increase susceptibility to fungal diseases [13, 14].

Routine Health Monitoring and Early Detection

Regular veterinary check-ups, screening of herds for dermatophytosis or respiratory mycoses, and immediate isolation of suspected cases help in early detection and rapid intervention. Prompt treatment prevents spread within herds and zoonotic transmission to humans.

Zoonotic Risk Mitigation

Many fungal infections (e.g., dermatophytosis, cryptococcosis, and sporotrichosis) are zoonotic. Farmers, veterinarians, and pet owners should practice personal protective measures, such as wearing gloves, masks, and protective clothing, when handling suspected animals. Public awareness campaigns are vital in educating animal handlers about the risks and safe handling practices [15].

CONCLUSIONS AND FUTURE DIRECTIONS

Fungal infections in livestock and companion animals remain a significant concern in veterinary medicine due to their impact on animal health, productivity, and welfare, as well as their zoonotic potential. Conditions, such as dermatophytosis, candidiasis, aspergillosis, and cryptococcosis, cause economic losses in the livestock industry and pose public health risks, particularly in immunocompromised individuals. Despite advances in diagnostics and therapeutics, challenges persist due to delayed detection, limited antifungal options, drug resistance, and the absence of effective vaccines. Improved diagnostic tools, such as molecular assays and NGS, are revolutionizing the identification of fungal pathogens, enabling rapid and precise detection. The emergence of antifungal resistance highlights the need for rational drug use, antifungal stewardship, and continuous surveillance. Furthermore, advances in immunology, genomics, and microbiome research are opening new avenues for understanding host–pathogen interactions and developing innovative therapies. In conclusion, veterinary mycology is an evolving field with critical implications for global food security, animal welfare, and public health. By combining traditional control measures with cutting-edge scientific advancements, we can better manage and eventually reduce the burden of fungal infections in animals.

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