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Therapeutic Considerations of Antimicrobial and Antifungal Uses for Oral Infections in Birds of Prey: A Short Review

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Abstract

Raptors are carnivorous predatory birds, represented by various species of hawks, falcons, eagles, owls, and vultures, with adaptations for active hunting and the types of food that comprise their diet. The health of the oral cavity is of utmost importance. Infectious diseases affecting the oral cavity and digestive tract can occur, leading to emaciation, lethargy, weakness, and death, with the most prevalent being those caused by *Candida* spp. and *Trichomonas gallinae*. Treatment with antimicrobial drugs such as nystatin and metronidazole is necessary, avoiding underdosing, and preventing cases of microbial resistance is highly important.

Keywords: Raptors; Digestive Tract; Oral Cavity; Nystatin; Metronidazole

Introduction

Raptors are represented by the orders Accipitriformes, Falconiformes, Strigiformes, and Cathartiformes, comprising various species of hawks, falcons, eagles, owls, vultures, condors, and buzzards. They exhibit adaptations for active hunting, such as curved beaks, sharp talons, and high visual acuity [1]. They are predatory birds, with a major part of their diet being carnivorous, and their preference for a specific type of prey depends on the species and food availability [2], including birds, rodents, reptiles, and fish when in the wild. Birds in captivity have a more restricted diet, commonly offered laboratory mice and rats, as well as birds like quails and chicks, but they should not be fed with birds from the wild whose cause of death has not been determined, as it may lead to the spread of diseases [3,4].

Within the avian species, the gastrointestinal tract is composed of various anatomical components, encompassing the beak, oropharynx (comprising the tongue, palate, and pharynx), esophagus, crop, proventriculus, ventriculus (gizzard), intestine, cecum, rectum, cloaca, and anus [5]. Raptors, being birds of prey, display beaks that have undergone morphological adaptations specific to their unique feeding habits, with the rhinotheca housing the nostrils and the gnathotheca playing a crucial role. Additionally, raptors possess a hyperkeratinized tongue, which plays a vital role in facilitating efficient food handling [2]. Strigiformes are an exception, as they possess a specialized sphincter that facilitates the smooth passage of ingested material. This distinctive anatomical feature replaces the crop, a dilation of the esophagus responsible for temporary food storage, which assumes particular importance during chick rearing [2].

In the context of their limited ability to digest keratinaceous substances present in feathers, beaks, and hair, the ventriculus (gizzard) plays a vital role in

the formation of regurgitated pellets. Contraction of the ventriculus leads to the aggregation of indigestible materials into these pellets, which exhibit considerable variation in size, shape, appearance, and odor. The examination of pellet contents offers valuable dietary insights into the consumed prey by raptors. Furthermore, any alterations in pellet composition may serve as potential indicators of underlying gastrointestinal pathologies [6-8].

The well-being of raptors heavily relies on maintaining optimal oral health. Clinical manifestations of pathological conditions affecting the oropharynx include emaciation, regurgitation, anorexia, head shaking, dyspnea, and dysphagia. These symptoms can arise from a diverse range of underlying etiologies, encompassing nutritional, traumatic, neoplastic and infectious origins [2]. Notably, infectious causes may involve microorganisms such as *Candida* spp. and *Trichomonas* sp. [9,10]. Treatment typically involves the administration of antimicrobial agents, and in severe cases, surgical intervention may be necessary to effectively address the condition [11].

Body of Paper

Trichomoniasis is an infectious disease caused by the protozoan *Trichomonas gallinae*. It can lead to the formation of caseous, diphtheritic, pinpoint, and painful lesions in the upper digestive and respiratory tracts, making it highly significant in raptors [12,13]. The microorganism is highly adapted to Columbiformes, often not manifesting clinical signs in birds of this order [6], and transmission occurs through the ingestion of contaminated prey. The disease causes prostration and depression. Cases of stomatitis were reported in Saker falcons (*Falco cherrug*) caused by *Pseudomonas aeruginosa*, a bacterium commonly associated with pneumonia in captive birds, following oral infection by *T. gallinae* [14], and a study comparing different orders shown that the most severe lesions, such as large abscesses in the oropharynx and lesions in the palate, occurred in the Southern Boobook owl (*Ninox boobook*) against to diurnal Accipitriformes and Falconiformes raptors [15].

Candidiasis (or moniliasis) is caused by *Candida* spp., an opportunistic fungal microorganism that affects the upper gastrointestinal tract, producing plaque-like lesions on the mucosa of the tongue, pharynx, and crop, or deep lesions unrelated to oral lesions. Clinical signs include dysphagia, hyporexia, vomiting, regurgitation, and prostration. Infection generally occurs orally through the ingestion of food or via fomites [12,16]. *Candida albicans* is considered an environmental contaminant and a normal part of the avian gastrointestinal microbiota. However, stress situations such as corticosteroid use, viral infections, and malnutrition can predispose birds to develop disease [17]. Prolonged use of antibiotics can lead to opportunistic *Candida* spp. infection [18]. Oral yeast infections have been associated with the ingestion of carcasses from domesticated animals in farm areas with antibiotic residues [9].

The diagnostic process for oral cavity diseases in raptors can be intricate, owing to the diverse range of potential etiologies involved. One of the essential steps in this process is the isolation of microorganisms, which can be accomplished through the collection of samples from the oral cavity. In instances where lesions are situated deep within the oral cavity, endoscopy serves as a valuable tool for visualization and sample retrieval [11,19]. Illustrative examples of caseous and diphtheritic lesions can be observed in (Figures 1 & 2) respectively.

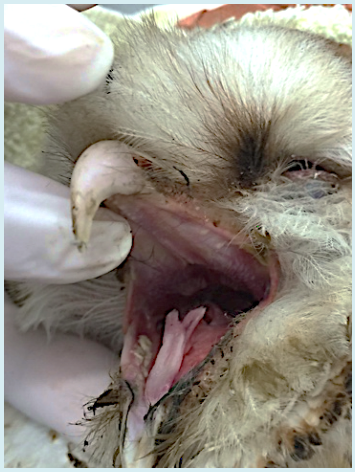

Figure 1: Diphtheritic Lesions (Arrow) in Oral Cavity in a Barn Owl (Tyto Furcata).

Figure 2: Caseous and Hyperemic Lesions (Arrows) in Palate in a Striped Owl (Asio Clamator).

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Arbitrary selection of antimicrobials or inadequate dosing can result in the development of resistance and, concurrently, a disruption in the normal microbiota of the digestive tract. Therefore, the efficacy of antimicrobial therapy is contingent upon a comprehensive clinical approach tailored to the specific needs of the individual and the surrounding environment. Tailoring treatment to target the particular microorganism responsible for the infection is of utmost importance [18].

The treatment of choice for *Trichomonas gallinae* infections is through nitroimidazoles [20]. Metronidazole, as well as carnidazole and ronidazole, are the most commonly used drugs [13,21]. Metronidazole is a heterocyclic nitroimidazole compound, and its mechanism of action is thought to be similar to that of nitrofurans. The antimicrobial action of these compounds is not well understood, but it is believed that they are reduced by bacterial flavoproteins, forming reactive and damaging intermediates to the microorganism's DNA [22]. Although metronidazole is the most commonly used and presents good results there may be some resistance in raptors undergoing treatment [23,24].

Nystatin is the drug of choice for yeast infections restricted to the digestive tract [16,13]. Nystatin is a polyene antifungal obtained from Streptomyces noursei, which is not absorbed by mucous membranes and skin. It is used in the treatment of fungal infections of the gastrointestinal tract and has no effect on the normal microbiota [22]. More aggressive or invasive infections may require the use of itraconazole, fluconazole, or amphotericin B [17], especially in cases of infection caused by *Candida albicans* that presents nystatin's resistance in some isolates [25]. The triazoles (itraconazole and fluconazole) cause plasma membrane alterations in the fungal microorganism, with itraconazole being more effective at lower doses compared to ketoconazole. Amphotericin B is indicated orally only for the treatment of digestive tract infections and, like nystatin, is a polyene antibiotic [26]. The recommended treatment doses [11,12,24,27] are found in (Figure 3).

Table 1 - Antifungal and Antibiotic Drugs and Dosages for the Treatment of Infections in Raptors

Agent	Action	Dosage
Carnidazole	Antibiotic	30 mg/kg orally every 24 hours, two doses
Fluconazole	Antifungal	2-5 mg/kg orally every 24 hours for 7-10 days
Itraconazole	Antifungal	5-10 mg/kg orally every 24 hours for 14 days
Metronidazole	Antibiotic	50 mg/kg orally every 24 hours for 7 days
		100 mg/kg orally every 24 hours for 3 days (in cases of resistance)
Nystatin	Antifungal	100,000 U/kg orally every 12 hours for 7-14 days

Figure 3: Antifungal and Antibiotic Agents and Dosages for the Treatment of Infections in Raptors

Conclusion

In the context of raptor health, *Candida* spp. and *Trichomonas gallinae* as microorganisms causing oral infections represent relatively frequent occurrences. Nonetheless, the availability of suitable antimicrobial and antifungal drugs specifically indicated for their treatment remains limited. Ensuring successful outcomes depends on prescribed adequate dosages and treatment durations, thereby mitigating the risks associated with underdosing and averting the potential emergence of microbial resistance against the administered drugs.

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