Selected Emerging Infectious Diseases of Squamata

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KEYWORDS

• Reptile • Viral • Fungal • Parasitic • Bacterial • Emerging • Disease

KEY POINTS

- Polymerase chain reaction (PCR) products should be validated with the use of DNA sequencing or probe hybridization to appropriately diagnose infectious disease agents.
- Diverse adenoviruses are strongly implicated in chronic enteric disease in a variety of squamates.
- Arenaviruses are strongly implicated as the cause of inclusion body virus of boid snakes.
- Diverse paramyxoviruses infect squamates; serologic methods are fraught with problems and PCR-based diagnostics are preferred.
- *Chrysosporium ophiodiicola* causes severe facial disfiguration and systemic mycosis in North American snakes.
- Site of infection is more important than exact host species for *Cryptosporidium*; *Cryptosporidium varanii* is the most common intestinal species in squamates and *Cryptosporidium serpentis* is the most common gastric species.

In comparative medicine, we often lack information in a given species, including which infectious agents are present and their clinical significance. When information is lacking in a given species, the best model to use is typically the closest relative from which data are available. This model requires knowledge of species relationships; many commonly used terms, such as reptile or lizard, can lead to erroneous understanding of relationships.

A common error is the idea of lizards as a group distinct from snakes. In squamate evolution, the earliest divergence is the geckos, followed by the divergence of the skinks, night lizards, plated lizards, and girdled lizards. The next groups to branch off were the teiids, lacertids, and amphisbaenids, and the remaining group, containing

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snakes, iguanids, agamids, chameleons, monitors, helodermatids, and anguids, is known collectively as the Toxicofera, named for the commonality of the presence of venom glands.[1] Snakes diverge in the middle of the squamates, and if snakes are removed, then lizards are not a monophyletic group. Snakes are a group of lizards, and a corn snake is a better model than a leopard gecko for a bearded dragon.

Within the past decade, several important advances have identified novel causes of significant emerging diseases of captive squamates. These advances have led to the development of diagnostic tools that are essential for squamate practitioners. It is important that reptile clinicians have an appreciation for the epidemiology, clinical signs, pathology, diagnostic options, and prognostic parameters for those diseases that have recently flooded the primary literature. This article provides an update on emerging squamate diseases reported in the primary literature within the past decade. For a comprehensive overview of reported infectious diseases, consultation of Jacobson E, editor, *Infectious Diseases and Pathology of Reptiles: A Color Atlas and Text* (Boca Raton, FL: CRC Press; 2007) is recommended.

CLINICAL APPROACHES TO INFECTIOUS DISEASES

Diagnostics

Because of the extensive list of organisms that may be normal flora in many contexts in diverse squamate species, it is imperative not to misinterpret culture and sensitivity reports and molecular diagnostic test results. The host-pathogen interaction can be definitively diagnosed only with the aid of histopathologic or sometimes cytologic analysis. Biopsies are therefore strongly recommended to diagnose, confirm, and characterize the nature of clinical infections in reptiles.

For microbial infections, culture and sensitivity of fresh biopsy tissue samples can be coupled with polymerase chain reaction (PCR) and sequencing to confirm specific pathogens and guide treatment approaches. Immunohistochemistry and in situ hybridization can be performed on formalin-fixed tissue sections to identify disease-causing agents and can subsequently guide therapeutic practices. However, samples should be processed into paraffin blocks quickly, and tissues that spend more than a few days in formalin become unsuitable for in situ hybridization. Cytology and special stains can aid in the quick ascertainment of potential diagnoses and guide clinician treatment recommendations pending receipt of PCR, biopsy, and culture/sensitivity results. Gram stains of impression smears can aid in characterizing bacterial pathogens. Wright-Giemsa and lactophenol cotton blue can be used to characterize yeasts and fungal hyphae. Acid-fast stains (Ziehl-Neelson or Fite) can be used to identify mycobacterial infections, *Nocardia*, and some parasitic infections, such as *Cryptosporidium*. *Cryptosporidium* stains acid-fast on fresh smears only and not in formalin-fixed tissues.

There are 2 major approaches to testing for infectious agents. These tests are based on (1) the animal's acquired immune response to an agent or (2) the presence of the agent.[2] Acquired immune responses can be further subdivided into 2 categories. Tests that evaluate antibody production against specific pathogens assess the lizard's humoral immune response. Some of these tests include enzyme-linked immunosorbent assays, hemagglutination inhibition, virus neutralization, and agarose gel immunodiffusion. Tests that evaluate the presence of cellular immunity, which is centered around the T-cell receptor, are not commonly available; assays that are used in human medicine include T-cell proliferation assays. It is important to consider when assaying humoral immunity that it is only part of the acquired immune response, and generally