Fungal infections in reptiles

Rachel E. Marschang

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Fungi

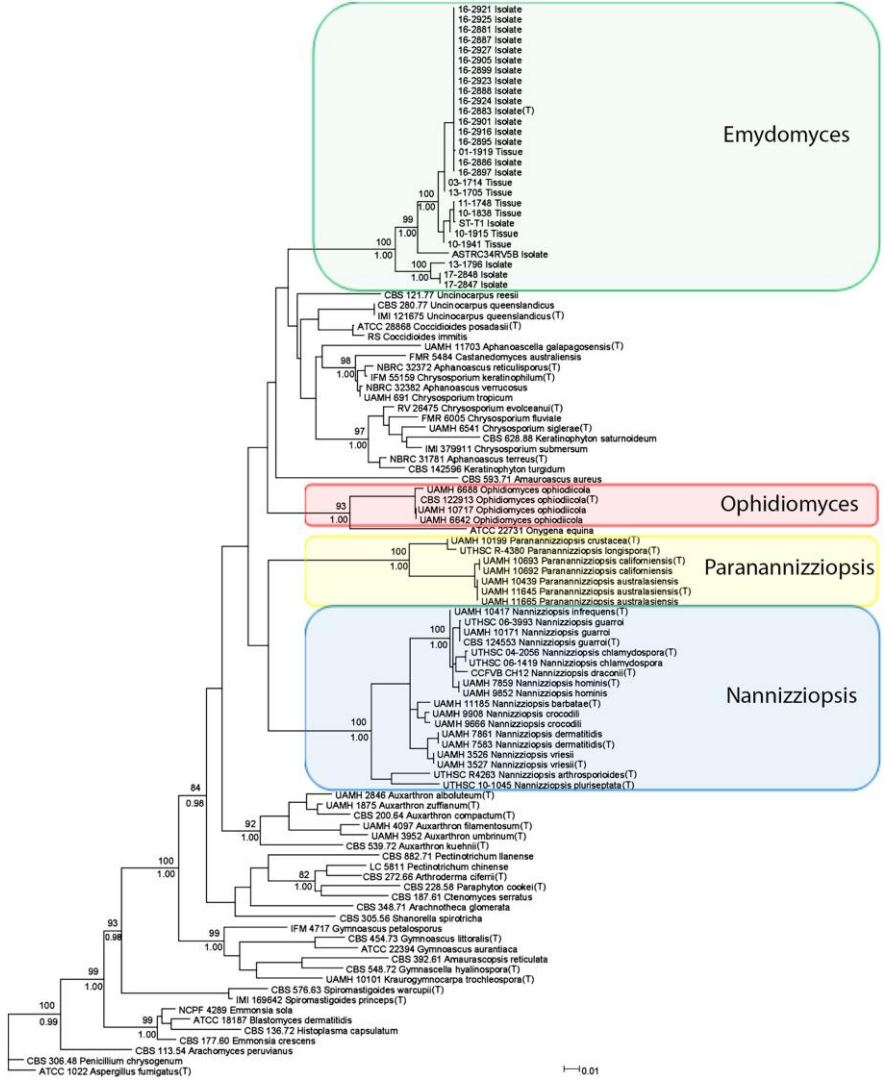
- Infection and disease often secondary
- Many fungi have been isolated from various lesions in reptiles:
  - *Aspergillus, Basidobolus, Geotrichum, Lecanicillium, Mucor, Saprolegnia, Penicillium, Fusarium, Purpureocillium, Trichophyton, Oospora, Alternia*
  - Yeasts and yeast-like fungi also described (*Candida*, *Cryptococcus*, *Trichosporon*)

Fungi

- Primary pathogens:
  - Onygenalean fungi
    - *Nannizziopsis* spp.
      - Mostly saurians and crocodiles
    - *Paranannizziopsis* spp.
      - Squamates and tuataras
    - *Ophidiomyces ophidiicola*
      - (Mostly) snakes
    - *Emydomyces testavorans*
      - Turtles
    - *Aphanoascella galapagosensis*
      - Galapagos tortoises
  - *Metarhizium* spp.
    - Most often described in chameleons
  - Microsporidia

Onygenales

- Several fungi in the order Onygenales are found in reptiles:
  - *Nannizziopsis* spp.
  - *Paranannizziopsis* spp.
  - *Emydomyces testavorans*
  - *Ophidiomyces ophidiicola*



Woodburn et al. J Clin Microbiol. 2019;57(2):e00628

Nannizziopsis spp.

- Originally described as *Chrysosporium* anamorph of *Nannizziopsis vriesii* (CANV)
  - Disease: Nannizziomycosis or „Yellow fungus disease“
  - *N. guarroi*, *N. chlamydospora*, *N. barbatus*, *N. draconii*, *N. arthrosporioides*, *N. plurispetata*, *N. dermatitidis*
  - *N. crocodili*

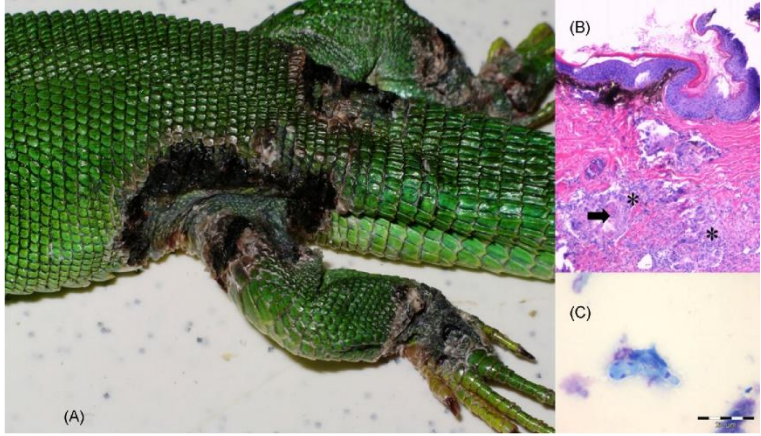
www.reptilerooms.com

Nannizziopsis spp.

- Host range
  - Most often in bearded dragons and green iguanas
  - Also in many other lizard species
  - Occasionally found in various snake species
  - *N. crocodili* in crocodilians in Australia
  - *N. barbata* is considered an emerging disease affecting a wide range of species in Australia (Wildlife Health Australia, 2025)
    - Including lizards and turtles
- Global occurance
  - Found in wild lizards in Australia

Nannizziopsis spp.

- Nannizziomycosis
  - Bumps, crusts, retained sheds, vesicles, ulcers, granulomas
  - Hyperkeratosis, necrosis
  - Emaciation, weakness
  - Slow progressive disease
  - Systemic disease possible
  - Koch‘s postulates fulfilled for *N. guarroi* in bearded dragons (Gentry et al., 2021) and *N. dermatititidis* in chameleons (Paré et al., 2009)

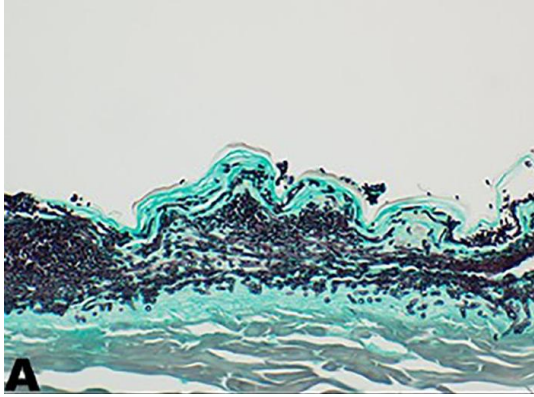


N. guarroi. Sigler et al. 2013. J Clin Microbiol 51(10):3338-3357

Image source: Tim Hyndman

Nannizziopsis spp.

- Diagnosis
  - Histology
    - Presence of hyphae and arthroconidia
  - Cytology (less reliable)
  - Fungal detection and identification
    - Culture
    - PCR
  - Samples:
    - Skin biopsies, sheds, swabs, impression smears, sticky tape preparation



Chronic erosive dermatitis, hyperkeratosis, intracorneal fungal hyphae. GMC stain.
Wong et al. 2025. Front Amphib Rept Sci 3.

Isolate from a *Pogona vitticeps*

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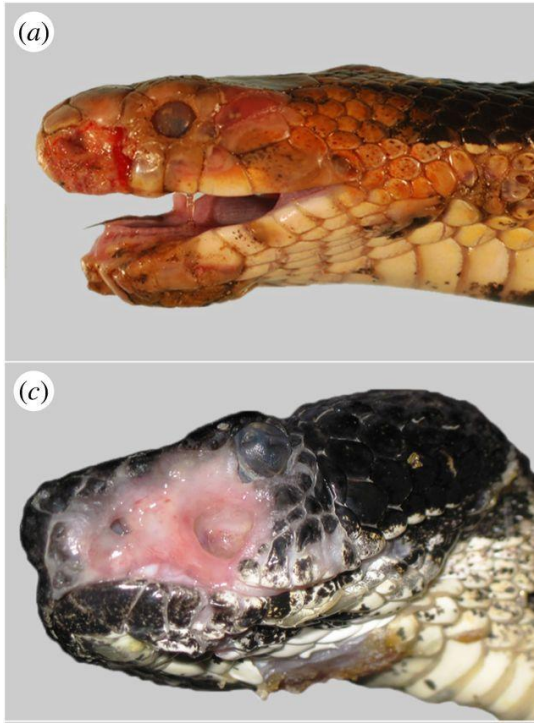
Nannizziopsis spp.: Treatment

- Can be difficult. Persistent infections described
- Surgical excision or debridement of lesions
- Antifungals: topical and systemic
  - Voriconazole (10 mg/kg PO once daily for 47 days – Van Waeyenberghe et al. 2010)
  - Terbinafine (25 mg/kg PO once daily for 80 days – Foltin and Keller, 2022)
  - Itraconazole: CAVE!
- Supportive therpy
  - Rehydration, pain medication, dietary supplementation, optimization of husbandry
- Disinfection
  - 3% bleach, 70% ethanol, possibly others

Ophidiomyces ophidiicola

- First described in snakes in the USA
  - in some cases associated with severe disease and population declines
- Also described in free-living snakes in Europe and Asia
- In snakes in human care in: North America, Europe, Asia, Australia



Lorch et al. Phil. Trans. R. Soc. B 2016;371:20150457

Oo – genetic variability

- 3 clades described so far:
  - Clade I (european clade): found in wild-caught snakes in Europe
  - Clade II (north american clade): wild snakes in North American and Taiwan as well as snakes in human care on various continents
  - Clade III: in snakes in human care in North America, Europe, and Australia. Related strains in wild-caught snakes in Taiwan

- Genetic diversity within the individual clades

Ophidiomycosis

- Asymptomatic
- Mostly diverse skin lesions (mild to severe)
  - Discoloration, displacement, thickening of scales/skin
  - Loss of scales
  - Vesicle formation
  - Necrotic to ulcerative dermatitis with formation of crusts
  - Increased frequency of ecdysis

N. tessellata with skin lesions. Courtesy of Sigrid Lenz

Ophidiomycosis

- Swelling, deformation of the face and skull, lesions within the oral cavity, stomatitis
  - Aspiration of infectious material-> pneumonia
  - Difficulty catching and consuming prey
- Lesions on and around the cloaca (cloacitis)-> difficulties with defecation or reproduction

N. natrix with skin lesions. Courtesy of Thomas Lindner

Ophidiomycosis

- Secondary:
  - Behavioral changes
  - Secondary infections
  - Weight loss
- Systemic disease (uncommon): Granulomas (described in liver, lungs, kidneys, spleen)
- Severe disease with high morbidity and mortality and impact on populations possible

N. natrix with skin lesions. Courtesy of Thomas Lindner

Oo – Transmission

- Transmission:
  - Natural infection likely mostly by direct contact with symptomatic or asymptomatic snake

- Detection in soil:
  - *Oo* can grow in sterile soil, growth inhibited by soil microbiota
  - Positive soil samples in areas with positive snakes

- Vertical transmission?

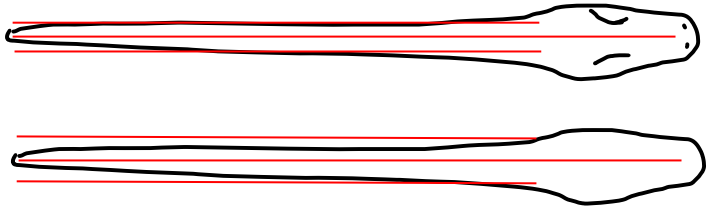
Ophidiomycosis

- Additional factors:
  - Season
  - Temperature
  - Co-infections
  - Stress?
  - Habitat?
  - Structure of the skin?
  - Microbiome?

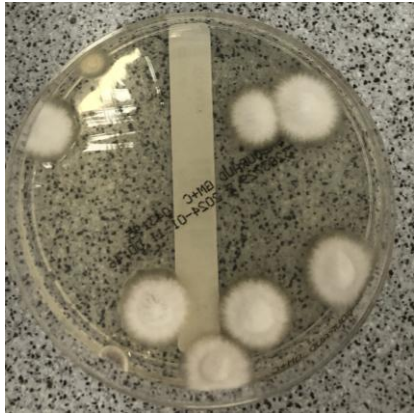
N. tessellata. Courtesy of Sigrid Lenz

Diagnosis

- PCR:
  - Material:
    - Skin swab (lesions)
    - Biopsy
    - Skin scraping, scale
    - Tissue
    - Shed skin



- Fungal culture:
  - Material: same as above



- (UV fluorescence)

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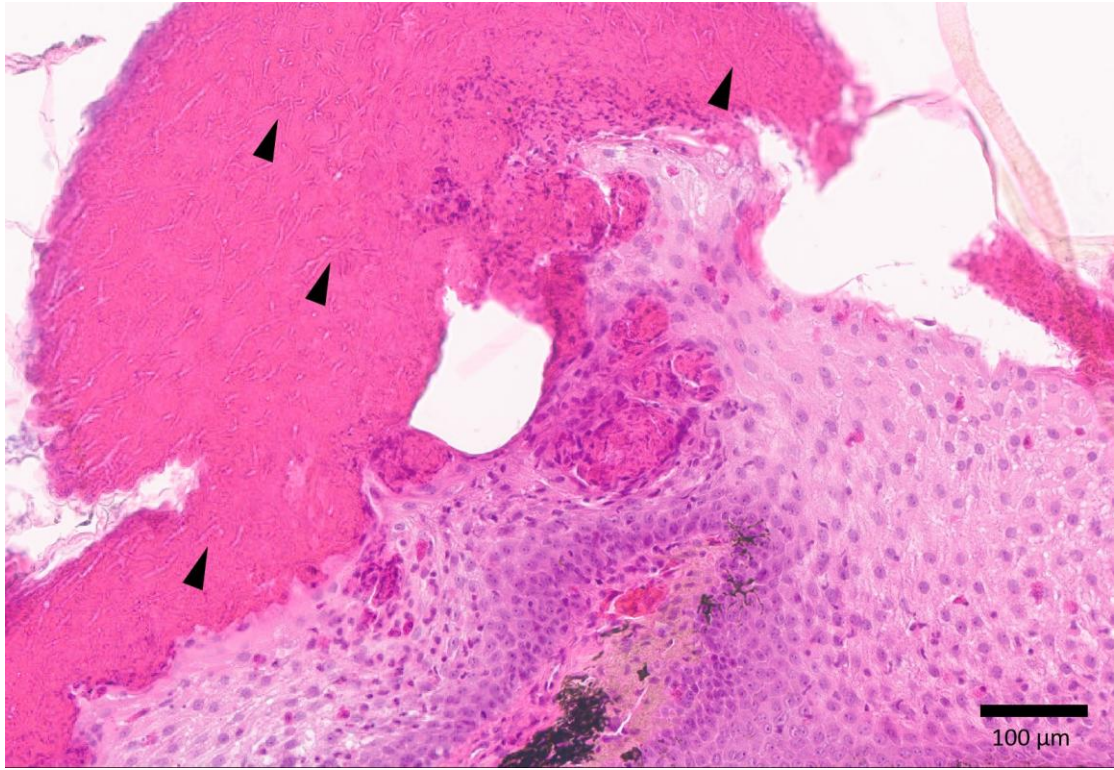
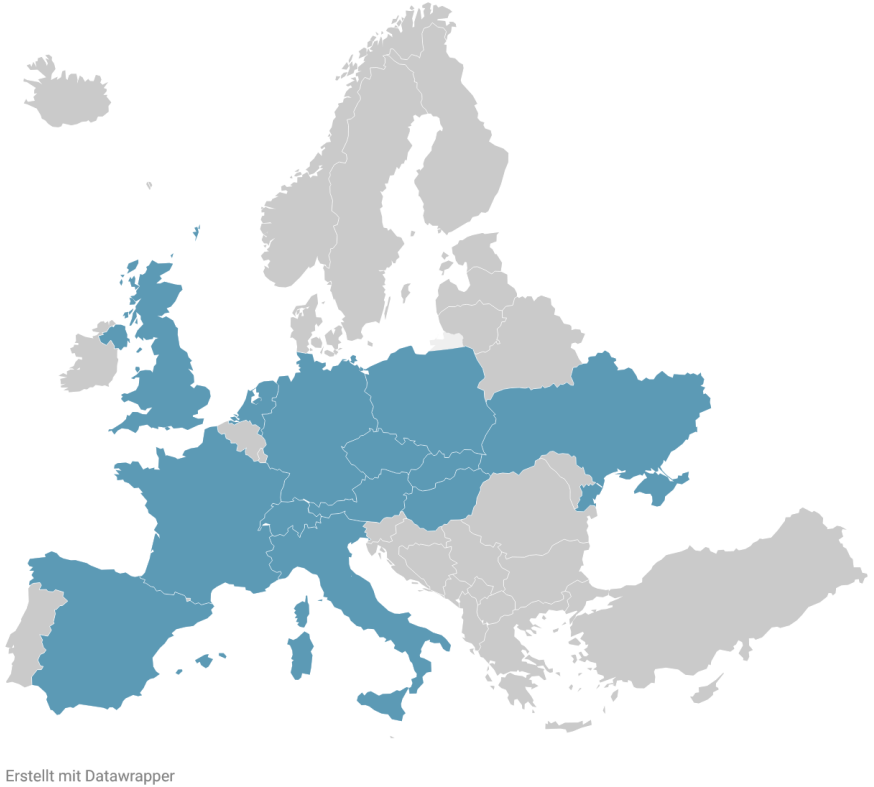
Diagnosis

- Histopathology:
  - Material: biopsy or tissue in formalin



Oo in Europe

- Detection in museum samples from Italy and Switzerland (Origgi et al., 2022)
- Earliest detection: 1959
- Detection in wild reptiles in Europe:
  - Austria, Czech Republic, France, Germany, Hungary, Italy, Netherlands, Poland, Slovenia, Spain, Switzerland, UK, Ukraine
  - Almost exclusively in colubrids
  - Hotspots (Switzerland)
- Clades I, II, III (Ladner et al., 2022)



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Oo – in managed collections

- In Europe
  - Sporadic detection
    - Colubridae, Viperidae, Pythonidae, Boidae, and Homalopsidae
    - Most often in species kept in humid environments
      - Anacondas

Anaconda with ophidiomycosis.
Courtesy of: Pierre Picquet

Prophylaxis

- Quarantine

  →Identification of asymptomatic carriers

- Desinfection:
  - E.g. 3% or 10% bleach, at least 2 min.; 70% ethanol, at least 2 min.
- Separation of positive and negative animals
- Avoid immunosuppression

Treatment

- Symptomatic treatment
- Analgesia
- Surgical debridement
- Antimycotics, e.g.:
  - Terbinafine e.g. nebulized or SC
    - Mixed results in *Nerodia* spp. 2 mg/ml, 30 min/Tag, 3-6 Monate (Haynes et al., 2023)
  - **CAVE:** Vorikonazol, Itrakonazol
- Desinfection of the environment, including anything coming into contact with the animals as well as regular substrate changes

Treatment

- Temperature influences *Oo* growth:
  - Growth inhibited below 7 °C
  - Severely limited below 14 °C
  - Strongest growth at 25 °C
  - Inhibited at 35°C
  - No growth >37 °C

FUNGAL ECOLOGY 17 (2015) 187–196

available at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/funeco

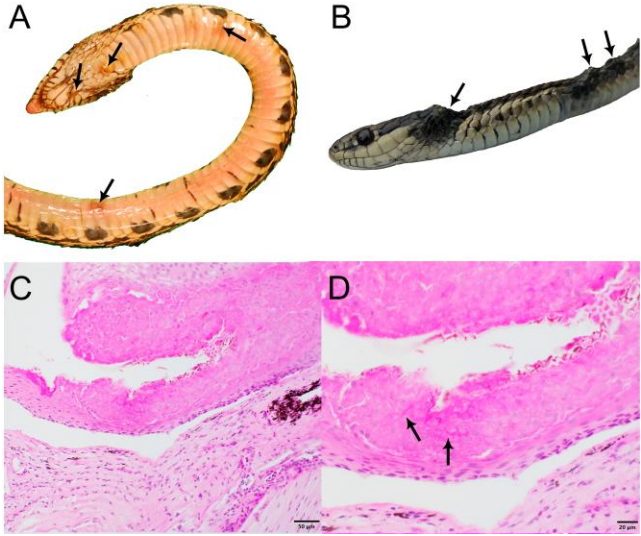
ELSEVIER

The natural history, ecology, and epidemiology of *Ophidiomyces ophiodiicola* and its potential impact on free-ranging snake populations

Matthew C. ALLENDER[a,1], *Daniel B. RAUDABAUGH*[b,d,1], *Frank H. GLEASON*[c,*], *Andrew N. MILLER*[d]

Paranannizziopsis spp.

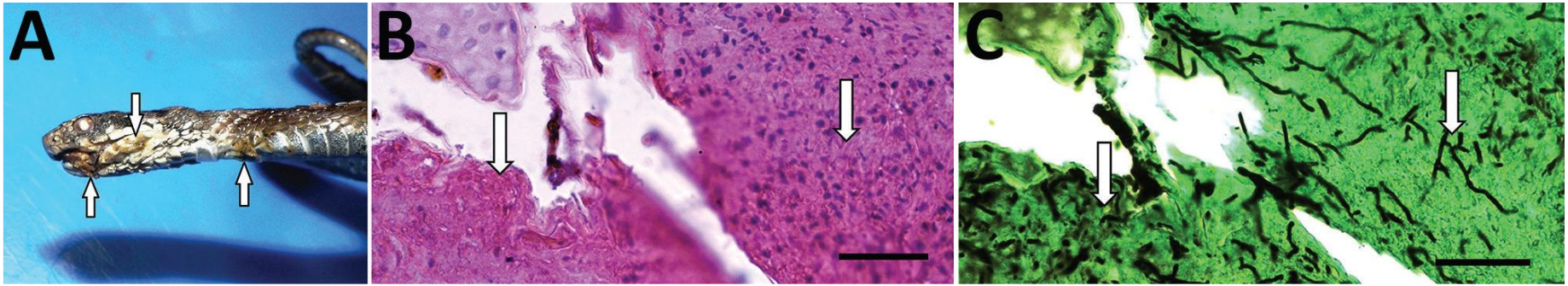
- Multiple species:
  - *P. australiasiensis*, *P. californiensis*, *P. crustacea*, *P. longispora*, *P. tardicrescense*
- Infect lizards, snakes, and tuataras
  - Most often in tentacled snakes
- Associated with skin lesions
- Co-infections with *Ophidiomyces ophidiicola* described



Lorch et al. 2023. Front Microbiol 14:1302586

Paranannizziopsis spp.

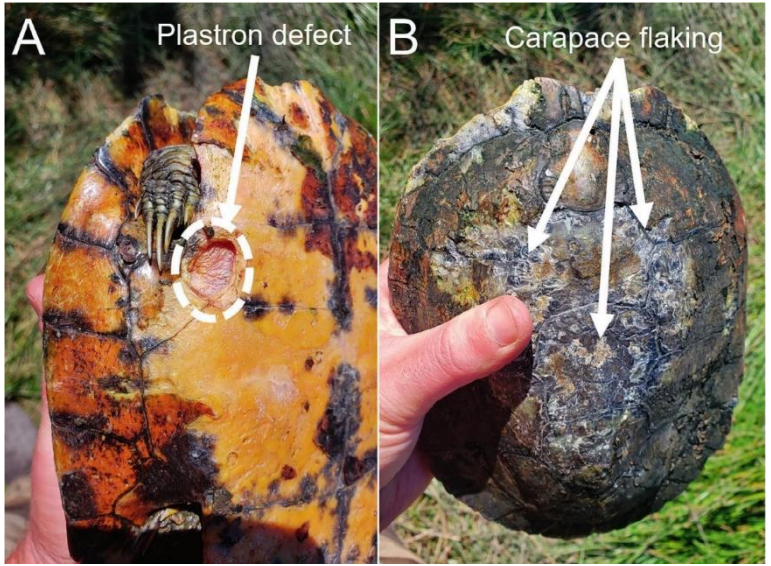
- Found in
  - Wild chameleons and snakes in the North America (Lorch et al., 2023)
  - Wild vipers in Spain (Blanvillain et al., 2024)
  - Wild lizards and snakes in Australia (Wildlife Health Australia, 2025)
  - Tuataras and snakes in managed collections in New Zealand, Australia, and North America



Blanvillain et al., 2024. Emerg Infect Dis 30:1000-1003.

Emydomyces testavorans

- First described in aquatic turtles in North America (Woodburn et al., 2019)
- Since described in multiple freshwater turtle species in the wild and in managed care in the USA



Lambert et al. 2021. Ichthyol Herpetol 109(4):958-962

Emydomyces testavorans

- Clinical signs and histopathological changes:
  - Discoloration/lightening of the shell
  - Ulcerative shell lesions
  - Can affect deeper regions of the shell
  - Inclusion cysts
  - Squamous cell metaplasia
  - Hyperkeratosis
  - Inflammation
  - Osteonecrosis

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Woodburn et al. 2021. Vet Pathol 58(3):578-586

Emydomyces testavorans

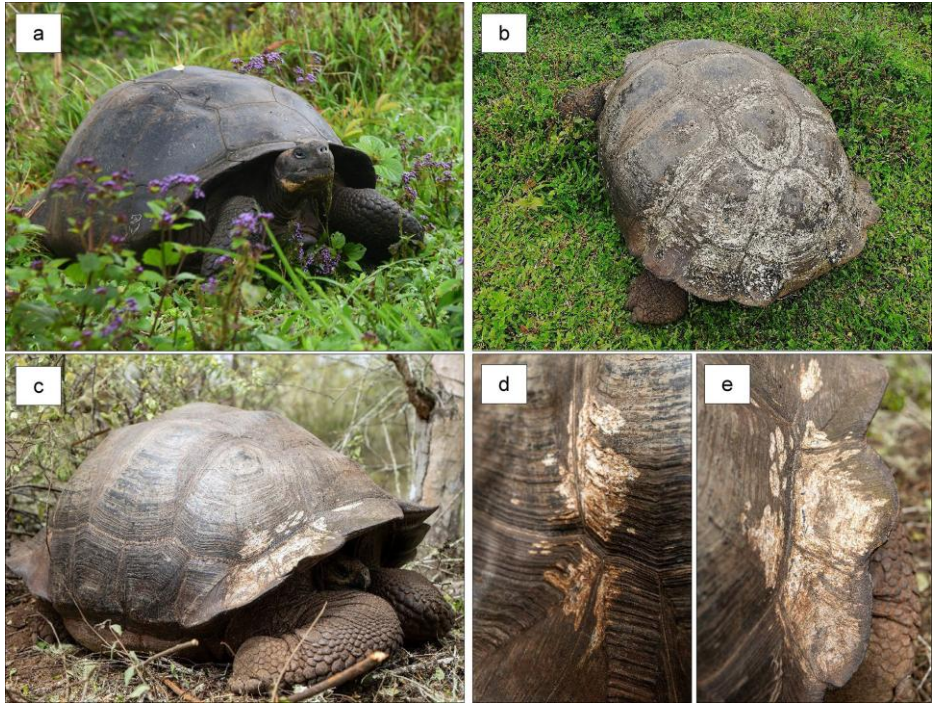
- Diagnosis:
  - Can be challenging
  - Detection of lesions:
    - Computer tomography
  - Histology
  - Fungal detection:
    - Culture
    - PCR
  - Samples for fungal detection:
    - Oral, cloacal, and shell swabs

Emydomyces testavorans

- Treatment
  - Also challenging
  - Long-term treatment necessary
  - Terbinafine baths or nebulization
  - Environmental disínfection (Liszka et al., 2025)
  - Debridement not always helpful

Aphanoascella galapagosensis

- Found on the shells of Galapagos tortoises in managed care and in the wild Associated with various skin lesions
  - Bleaching
  - Whitish lesions
  - Scute erosions



Nieto-Claudín et al. 2025. Mycopathologia 190:48. https://doi.org/10.1007/s11046-025-00955-

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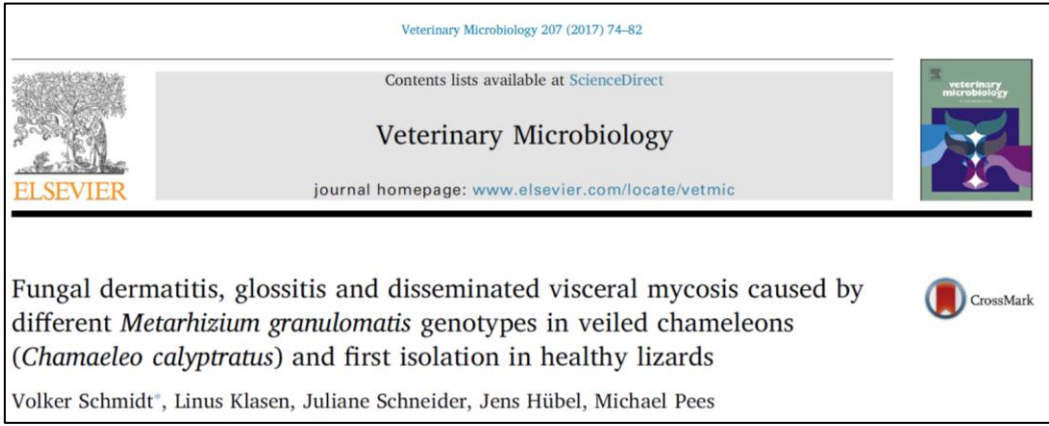
Metarhizium spp.

- *Metarhizium granulomatis* and *M. viride*
  - Formerly known as *Chamaeleomyces* spp.
- Cause granulomatous disease in lizards (esp. Chameleons)
- Mostly reported from Europe

Metarhizium spp.

- *Metarhizium granulomatis*
  - Detected mostly in veiled chameleons, also in pather chameleons and one bearded dragon
  - Pathological findings only reported in veiled chameleons
    - Anorexia, skin lesions, emaciation
    - Granulomatous glossitis, pharyngitis, dermatitis, visceral mycosis
  - Treatment:
    - Terbinafine, nystatin tried
    - No cure, but may extend life expenctancy



Veterinary Microbiology 207 (2017) 74–82

Contents lists available at ScienceDirect

Veterinary Microbiology

journal homepage: www.elsevier.com/locate/vetmic

Fungal dermatitis, glossitis and disseminated visceral mycosis caused by different *Metarhizium granulomatis* genotypes in veiled chameleons (*Chamaeleo calyptratus*) and first isolation in healthy lizards

Volker Schmidt*, Linus Klasen, Juliane Schneider, Jens Hübel, Michael Pees

Metarhizium spp.

- *Metarhizium viride*
  - Detected in various chameleon species and in bearded dragons
  - Anorexia and apathy
  - Glossitis, stomatitis, and pharyngitis, visceral mycosis and death
  - Diagnosis:
    - Cytogoy, histology, culture

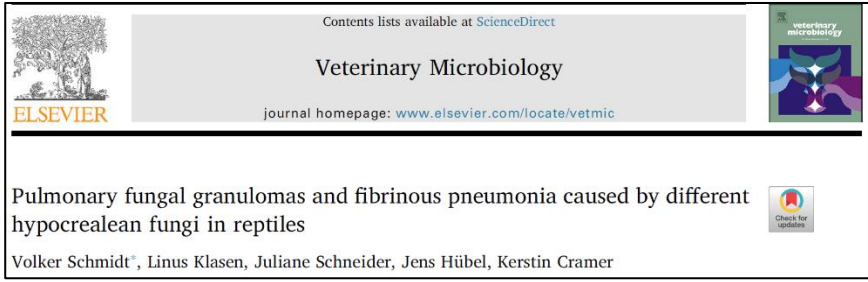
Veiled chameleon tongue. Schmidt et al. 2017

Foci on lung and liver, bearded dragon Schmidt et al. 2017

https://doi.org/10.1128/JCM.02206-16.

Metarhizium spp.

- Other *Metarhizium* spp. and *Beauveria* spp.
  - Primary pathogens of insects (e.g. *M. anisopliae* and *M. robertsii*)
  - Granulomatous pneumonia and/or coelomitis
  - Crocodilians, tortoises, sea turtles, and various lizard species
  - North and South America and Europe



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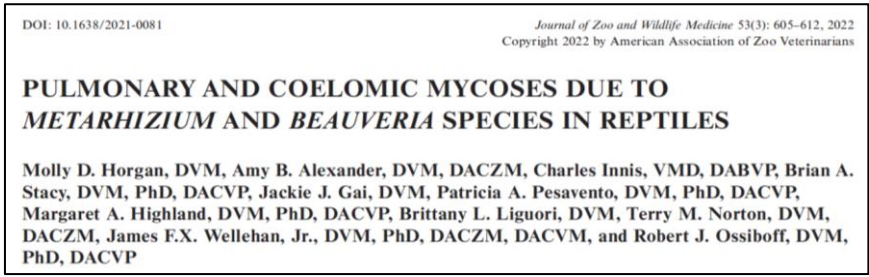
Veterinary Microbiology

journal homepage: www.elsevier.com/locate/vetmic

Pulmonary fungal granulomas and fibrinous pneumonia caused by different hypocrealean fungi in reptiles

Volker Schmidt*, Linus Klasen, Juliane Schneider, Jens Hübel, Kerstin Cramer



DOI: 10.1638/2021-0081

Journal of Zoo and Wildlife Medicine 53(3): 605–612, 2022

PULMONARY AND COELOMIC MYCOSES DUE TO *METARHIZIUM* AND *BEAUVERIA* SPECIES IN REPTILES

Molly D. Horgan, DVM, Amy B. Alexander, DVM, DACZM, Charles Innis, VMD, DABVP, Brian A. Stacy, DVM, PhD, DACVP, Jackie J. Gai, DVM, Patricia A. Pesavento, DVM, PhD, DACVP, Margaret A. Highland, DVM, PhD, DACVP, Brittany L. Liguori, DVM, Terry M. Norton, DVM, DACZM, James F.X. Wellehan, Jr., DVM, PhD, DACZM, DACVM, and Robert J. Ossiboff, DVM, PhD, DACVP

Journal of Comparative Pathology 201 (2023) 16–22

Contents lists available at ScienceDirect

Journal of Comparative Pathology

journal homepage: www.elsevier.com/locate/jcpa

Infectious disease

Infections by entomopathogenic fungi in common green iguanas (*Iguana iguana*) in captivity in Brazil

Eduardo Ferreira-Machado [a, b], Pedro E Navas-Suárez [a, b], Ticiana B Ervedosa [a], Ketlyn B Figueiredo [a], Ana C S R de Carvalho [a], Juliana P F Takahashi [a], Lidia M Kimura [a], Leonardo J T de Araújo [a], Natália C C de Azevedo Fernandes [a, b], Thaís C Sanches [c], Luana Rivas [c], Mayra Frediani [c], Ticiana M Zwarg [c], Guilherme R Blume [d], Rômulo S A Eloi [d], Letícia B de Oliveira [d], André L R M Santos [d], Nicolas T C das Chagas [e], Juliana M Guerra [a, *]

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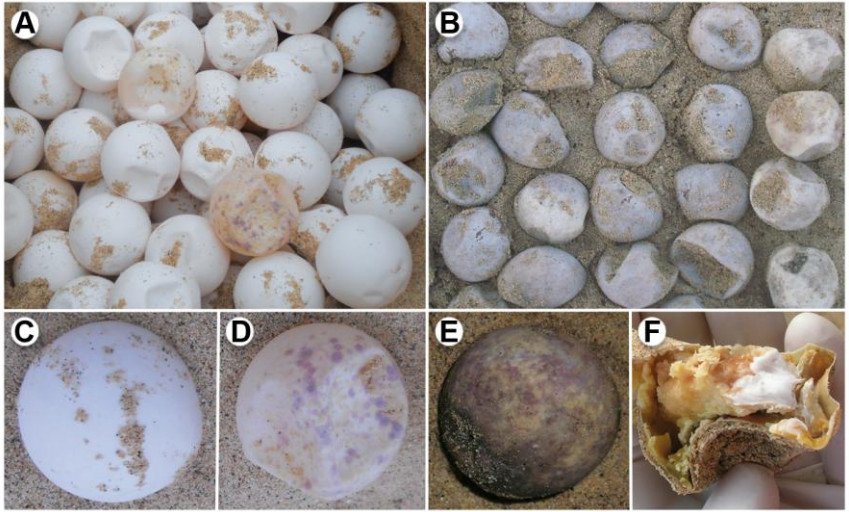
Fusarium spp.

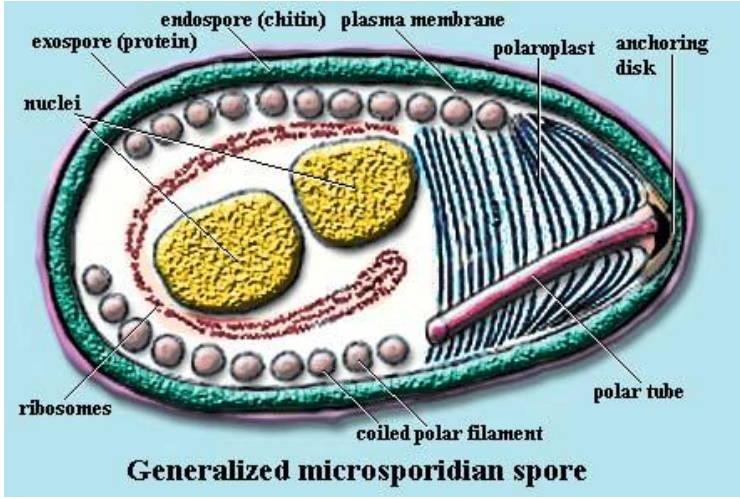
- *F. solani* and others
  - Found in soil, plants, water, marine environment
  - Involved in mycoses of aquatic reptiles
  - Cutaneous and systemic disease
  - Fusariosis of sea turtle eggs
    - Treatment witn topical 10% iodine in alcohol, topical ketoconazole
    - Environmental contamination



Caretta caretta nests affected by *Fusarium*. Sarmiento-Ramírez et al. 2014. PLoS One 9(1):e85853. https://doi.org/10.1371/journal.pone.0085853

Microsporidia

- Obligate intracellular fungi
- Many different genera described
- Spores can survive outside the host
- Infection often subclinical in immunocompetent mammals and birds
- Disease in immunocomprimised hosts



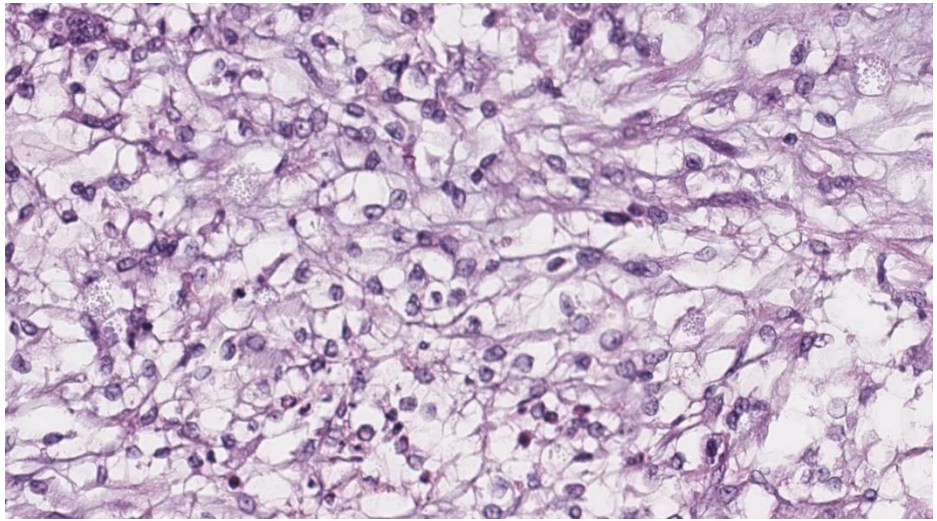
http://palaeos.com/eukarya/stem_metazoa/microsporidia.html

Microsporidia

- In reptiles:
  - Microsporidia in several genera described so far (*Encephalitozoon*, *Heterosporis, Pleistophora* and *Enterocytozoon*)
- In snakes:
  - Various genera and species (*Pleistophora*, *Heterosporis*, *Enterocytozoon*)
  - Multiple reports
  - Most often affecting the musculature (granulomatous myositis)

Microsporidia

- In bearded dragons:
  - only *Encephalitozoon*
  - *Encephalitozoon pogonae* (Sokolova et al., 2016), closely related to *E. cuniculi*
  - Detected in granulomas, necrosis in various organs
  - Vasculitis
    - Possible association with aneurysms suggested (Kaiser et al., 2021)

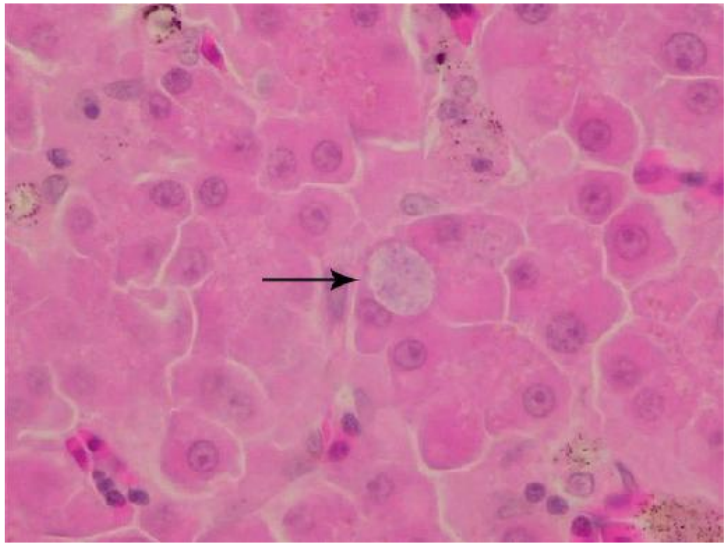


E. pogonae, granulomatous myocarditis

Microsporidia

- Co-infections with other potential pathogens described
  - Adenoviruses
  - Isospora

Liver of a bearded dragon with a cyst with morphology consistent with a microsporidia (source: Schilliger et al., 2016, Tierärztl Praxis 44(5):355-358)



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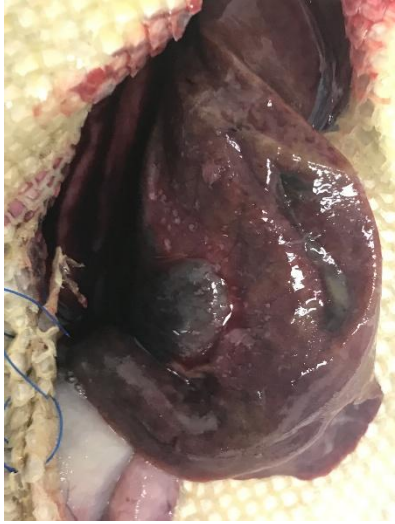
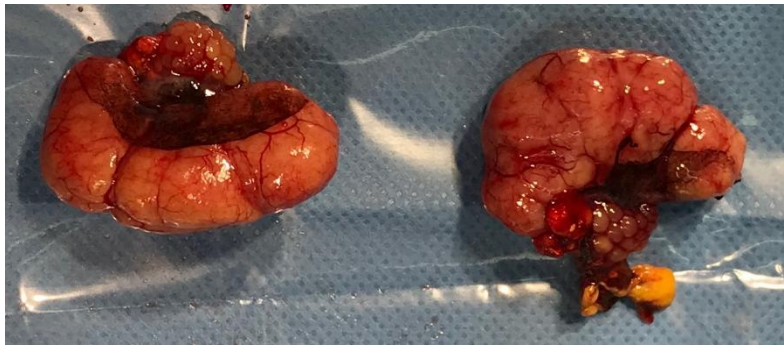
Adenoviruses and microsporidia

- Australia (Llinas et al., 2021):
  - Bearded dragon with ovarial granulomas
    - Microsporidia detected in the granulomas histologically
    - Affected animal and 5 others in collection were all positive for *E. pogonae* and LAdVB
    - Another animal from another collection that also had granulomas was also positive for *E. pogonae*, but negative for LAdVB





Bearded dragon liver and ovarian granulomas, images courtesy of Joshua Llinas

Microsporidia

- Diagnosis:
  - Histology
  - PCR
  - Found in 19.4% of examined samples

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THE OFFICIAL PUBLICATION OF THE ASSOCIATION OF REPTILE AND AMPHIBIAN VETERINARIANS

ORIGINAL RESEARCH

The Journal of Herpetological Medicine and Surgery, Volume 34, No. 4, 2024 pp. 262–266
DOI: 10.5818/JHMS-D-24-00013

Adenoviruses and *Encephalitozoon pogonae* in Samples from Bearded Dragons (*Pogona* spp.) in Europe

Rachel E. Marschang*, Lisa Schüler

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Thank you for your attention!

ecvm European College of Veterinary Microbiology

ARAV ASSOCIATION OF REPTILIAN AND AMPHIBIAN VETERINARIANS

ECZM EUROPEAN COLLEGE OF ZOOLOGICAL MEDICINE