Long, Rachel B., et al. "Host factors and testing modality agreement associated with Ophidiomyces infection in a free-ranging snake population in southeast Ohio, USA." *Journal of Zoo and Wildlife Medicine* 50.2 (2019): 405-413.

Abstract: Snake fungal disease (SFD) is an emerging mycotic disease caused by Ophidiomyces ophiodiicola, and has been demonstrated to impact snake populations of conservation concern in the United States negatively. Although Ophidiomyces has been shown to affect diverse taxa and to have a broad distribution, host factors associated with infected individuals and optimal testing protocols are not yet well characterized. The purpose of this study was to evaluate host factors and agreement across testing modalities associated with Ophidiomyces infection in a free-ranging snake population in southeast Ohio. Wild-caught snakes were swabbed and biopsied to test for Ophidiomyces via quantitative polymerase chain reaction (qPCR), culture, and histopathology. The host parameters assessed were species, sex, snout–vent length, body weight, month captured, and presence of grossskin lesions. A total of 8/30 individuals across three species—Black Racers (Coluber constrictor), Grey Ratsnakes (Pantherophis spiloides), and Eastern Gartersnakes (Thamnophis sirtalis sirtalis)—tested positive via at least one testing modality for Ophidiomyces infection. There were no associations between sex, snout–vent length, or weight and Ophidiomyces infection status. A higher proportion of individuals with gross lesions tested positive for Ophidiomyces than those without gross lesions, and most individuals that tested positive were caught in April or May. A low level of agreement was observed across testing modalities. Swab qPCR identified the most Ophidiomyces-positive individuals, and fungal culture identified the fewest at 0 individuals. Although there are limitations associated with a sample size of 30, these findings support the potential of this pathogen to infect individuals broadly across species and size, highlighting the relevance of this disease for snake conservation efforts. They also suggest that although little agreement was observed across test modalities, the concurrent use of multiple modalities is a more sensitive method for characterizing prevalence and distribution of Ophidiomyces.

Introduction:

* Clinical signs associated with SFD – Hyperkeratosis, dermal ulceration, blistering, pustules, subcutaneous nodules, dermal swelling, erythema.
	+ Primarily cutaneous – Head, neck, dorsum, tail; systemic spread also documented.
* Current dx techniques are associated with a significant rate of false negatives, likely underestimating the true prevalence of Ophidiomyces.
	+ Skin swab qPCR – significant potential for false negatives even with clinical signs due to differences in swabbing techniques and stage of infection.
* Purpose of study – Assess overall prevalence of positive individuals in a population of wild snake in Ohio, evaluate host factors that may be associated with positive individuals, comparing agreement of testing modalities.

M+M:

* 30 snakes captured 2014-2017 at The Wilds (semi-free ranging conservation facility).
* PE, PIT tag, qPCR skin swab (lesions, normal skin). Biopsy for histo and qPCR. Fungal culture samples.

Results:

* 40% snakes had clinical signs (skin lesions).
* 24% positive by qPCR in swabs, 12% positive with qPCR on tissue biopsy.
* Only one positive on both swab and tissue qPCR, low agreement.
* Moderate agreement between qPCR and clinical signs.
* No samples positive by fungal culture.
* No agreement between culture and other modalities.
* 6 snakes had histo lesions suggestive of infection (swab and PCR not submitted for one of six of those).
* Characteristic dermal granulomas seen in advanced cutaneous cases not observed in this population.
* Only a single individual was detected positive with qPCR and also had histo evidence of disease – poor agreement.
* Host factors – Snakes captured in April and May significantly more positive individuals. 2017 higher prevalence vs other years. Black Racers highest proportion of infected individuals followed by Grey Ratsnakes and Eastern Gartersnakes. No significant association between dz and sex or body mass.

Takeaway: Multiple testing modalities recommended to increase diagnostic sensitivity for SFD.

Dibadj, Bryce, et al. "Investigating Agreement between Snake Sheds and Skin Swabs in Detection of Ophidiomyces ophidiicola." *Journal of Herpetological Medicine and Surgery* 31.2 (2021): 119-123.

Abstract: Ophidiomycosis, an infectious disease of snakes caused by the fungus Ophidiomyces ophidiicola, is known to cause skin lesions and, in some cases, deeper infections, and even death. It has been documented in captive snakes worldwide and in free-ranging snakes in the United States and Europe. Diagnostic limitations have impeded characterization of the epidemiology of this disease and subsequent efforts to improve clinical care and conservation outcomes. The purpose of this research was to evaluate the efficacy of qPCR of snake sheds as a noninvasive diagnostic tool for the detection of O. ophidiicola, compared to swabs prior to and following the shed. We tested shed pieces from grossly observed skin lesions or mid body sections if disease was not obvious, and matched skin swabs from 68 animals using a qPCR assay specific for O. ophidiicola. There was nearly complete agreement between the qPCR results of sheds and swabs (Cohen’s kappa 1⁄4 0.97) and sheds were 100% sensitive and 97% specific for apparent ophidiomycosis, with a 97% negative predictive value and a 100% positive predictive value. Our results indicate that qPCR of snake sheds is a reliable detection method for the presence of O. ophidiicola, as this technique has high agreement with peri-ecdysis skin swabbing. Although this technique can be used for noninvasive pathogen detection in captive individuals with known histories, results from snake sheds from free-ranging animals with no knowledge of associated clinical signs should be interpreted with caution and additional surveillance is necessary in these cases.

Introduction:

* The pathology of *O. ophidiicola* is due in part to keratinase activities that cause skin lesions as fungus invade tissues.
* Based on presence or absence of gross lesions and fungus, individual snakes can be assigned to one of five categories:
	+ Negative – No lesions, qPCR negative.
	+ *Ophidiomyces* present – No lesions, qPCR positive.
	+ Possible ophidiomycosis – Lesions present, qPCR negative.
	+ Apparent ophidiomycosis – Lesions present and qPCR positive.
	+ Confirmed ophidiomycosis – Histo showing arthroconidia, positive qPCR/culture.
* Pros and cons of biopsy vs skin swabs:
	+ Biopsy – Tissue sample for histo, qPCR, and fungal culture, but invasive, require significant amt of time and trained individuals, samples restricted to specific point on body.
		- Restricting sampling to one point on the body may decrease the chances that an infected area is tested in animals where dz is nonhomogeneously distributed, increasing the likelihood of sampling error.
	+ Swab – Less invasive, can be used for qPCR or fungal culture, shown to be as sensitive as biopsy in one study. Requires handling the snake and can be time consuming for large collections.
* Snake sheds – Potential dx sample that can be collected opportunistically and noninvasively. Objective of this study to determine agreement between snake sheds and swabs for detection of SFD using qPCR. DNA on shed likely degrades over time.

M+M:

* Sheds and swabs taken from 9 different snake species.
* Snakes swabbed on dorsum and ventrum of head, emphasis on lesions if present.
* Sheds opportunistically collected. Sampled lesions or an area from a central body location on the dorsum.

Results:

* All qPCR positive sheds from Lake Erie water snakes (33/38).
* Sheds from all other spp were qPCR negative.
* Sensitivity of snake sheds for detection of DNA in snakes with apparent ophidiomycosis was 100%, specificity 97%.
* Positive predictive value 97%, negative predictive value 100%.
* Nearly complete agreement between qPCR results of sheds and swabs
* Snakes should be assessed for both gross disease and molecular detection before declaring them healthy.

Takeaway: Strong agreement between qPCR results from sheds and swabs, testing sheds was highly sensitive and specific for detecting *Ophidiomyces* DNA in snakes with apparent ophidiomycosis.

**Preliminary evaluation of a novel insect-based sausage diet for juvenile corn snakes (Pantherophis guttatus)**

Kimberly L. Boykin ; Karina Butler-Perez ; Cameron Q. Buck ; Jordan W. Peters ; Mark A. Mitchell.

JHMS 2020;30(3):129-136

Diet options for captive snakes are limited at the commercial level. Sausage diets can be developed that allow for the use of alternative protein sources (e.g., insect based) and address issues related to the feeder mice industry (e.g., expense, calorie dense, injuries from live prey, and zoonoses). **In this 4-month-long cross-over feeding trial, juvenile male corn snakes (*n* = 9; *Pantherophis guttatus*) were fed either an experimental insect-based sausage diet or a frozen-thawed mouse. Each diet was fed for 2 months during the cross-over study. Snakes were fed twice weekly at 15% of their body weight. If snakes refused to eat, force feeding was instituted. Physical examinations and morphometrics, including weight, snout–vent length, tail length, and girth, were measured at the beginning and end of each 2 month period. Feces were collected to assess apparent digestibility of both diets, and palatability was determined by consistent voluntary ingestion.** There were no significant changes between diet groups regarding health or growth parameters of snakes. Changes in weight were significant, but only as a factor of time (*F* = 14.083, *P* = 0.003). Sodium (–54.15%) and iron (10.4%) for the sausage diet and copper (20.15%) and manganese (–10.1%) from the frozen mouse diet were poorly digested. In regard to palatability, willingness to eat the offered diet on a consistent basis was significantly lower for the snakes receiving the sausage diet (*P* = 0.028). The results of this study suggest that insect-based sausages can be used to diversify captive snake diets as long as palatability is addressed.

**Background**

* Processing whole vertebrate prey or non-traditional sources of protein into sausage casings 🡪 allows ability to develop diets to meet nutritional needs
* Insect-diet addresses issues related to feeder mice industry – expense, calorie dense, injuries from prey
* N = 9 juvenile corn snakes, randomized crossover study
	+ Fed experimental insect-based (black soldier fly larvae) sausage or frozen-thawed mouse
	+ Snakes that refused to eat for 2 meals were force fed

**Key points**

* No differences in growth or health parameters between diets 🡪 suggests black soldier-fly larvae provides appropriate nutrition
* Most nutrients >50% digestible 🡪 sausage comparable for DM, crude protein, crude fat, ash, Ca, P, and K to frozen mice
* Na and iron poorly digested from sausage diet 🡪 may be due to non-heme iron (less absorbable form) from more plant ingredients in larvae diet
* Copper and manganese poorly digested from mouse diet 🡪 Low copper may be from high zinc levels
* Na and manganese produced negative digestibility coefficient 🡪 more concerning, negative digestibility of manganese is rare and unlikely with ingesting whole prey
* Palatability of sausage was lower than mouse diet 🡪 most required mouse blood or skin covering to entice appetite
* Regurgitation was common following force-feeding of sausage diet

**Take home**: insect-base sausage diet produced comparable growth rates to mouse diet BUT has poor palatability, Na and iron poorly digested from sausage

**Comparison of Two Sampling Methods for Bacterial Culture of Salmonella enterica ssp. arizonae from Burmese Pythons (Python bivittatus).**

Buscaglia NA, Weinkle TK, McDonough PL, Kollias GV.

Journal of Herpetological Medicine and Surgery. 2019;29(1-2):40-48.

**Cloacal swabs and feces were collected for four consecutive months from 19 young, healthy Burmese pythons (Python bivittatus) that were culture-confirmed, asymptomatic carriers of Salmonella enterica ssp. arizonae (S. arizonae). Standard culture protocols were used on 152 samples in total (76 fecal samples and 76 cloacal swabs). Comparison of the two sampling methods for each month and over the combined 4 months using McNemar's χ2 test** revealed that the two methods were not statistically different at the P < 0.05 level. However, of the cloacal swabs, 71 (93%) of 76 samples yielded positive cultures of S. arizonae, 15 (79%) of 19 snakes had no negative cloacal swabs, 1 (5%) snake had more than one negative cloacal swab (but not consecutively), and all snakes had positive cultures in two of the months. Of the fecal samples, 64 (84%) of 76 samples yielded positive cultures of S. arizonae, 13 (68%) of 19 snakes had no negative fecal samples, 4 (21%) snakes had more than one negative fecal sample (3 of which were in consecutive months), and all months had at least one negative culture. Serotyping of confirmed S. arizonae isolates identified three different serotypes. This study provides the first evidence-based data to support the statistical equivalency of cloacal swabs and fecal samples for the isolation of Salmonella from reptiles. Cloacal swabs are easy and convenient to collect and are less prone to confounding factors than are fecal samples, so clinicians can feel comfortable using this sample collection method.

**Background**

* *Salmonella* is reported as an opportunistic pathogen in some reptiles
	+ may cause salpingitis, dermatitis, enteritis, pneumonia, osteomyelitis, endocarditis, septicemia
* Zoonotic: transient GI signs but in immunocompromised sometimes fatal, meningitis, osteomyelitis, arthritis, lymphadenitis, sepsis
* Most commonly diagnosed on culture, PCR, ELISA
	+ Culture Sp and PPV high, Sn and NPV low

**Key Points**

* No statistical difference between feces and cloacal swabs per month or combined over 4 mo
	+ Sensitivity of cloacal swabs was greater than fecal - overgrowth of non-*Salmonella* in fecal samples
	+ 2 cloacal swab cultures 1 month apart are likely to identify carriers
	+ 3 fecal cultures 1 month apart is likely needed to ID all carriers
	+ Highest detection rate when fecal culture and cloacal swab combined
* *Salmonella arizona* + 3 new serotypes identified (48:I-Z35, 35:I-Z, 38:(K)-Z35)
* No gross or histo lesions, cultures of hepatic tissues were positive, not spleen; all cloacal swabs at euthanasia were positive

**Conclusions**

* *S. arizonae* may be part of Burmese python normal enteric flora
* Although not stat sig, cloacal swab may be slightly more sensitivity than fecal culture for *Salmonella* detection in young Burmese pythons

Two cloacal swabs at least 1 month apart should detect shedding as opposed to 3 monthly fecal samples

**Effect of intracoelomic administration of alfaxalone on the righting reflex and tactile stimulus response of common garter snakes (Thamnophis sirtalis)**

AJVR: 2019;80:144–151

OBJECTIVE T**o determine the intracoelemic (ICe) dose of alfaxalone required to induce loss of righting reflex (LRR) in garter snakes (Thamnophis sirtalis) and to evaluate the tactile stimulus response in unanesthetized and alfaxalone anesthetized snakes.**

ANIMALS 8 healthy mature garter snakes.

PROCEDURES During the first of 3 phases, snakes received each of 3 doses (10, 20, and 30 mg/kg) of alfaxalone, ICe, with a 2-week washout period between treatments. Times to LRR and return of righting reflex were determined after each dose. During phase 2, unanesthetized snakes underwent tactile stimulation testing with Semmes-Weinstein monofilaments once daily for 3 consecutive days to determine the baseline tactile pressure required to elicit purposeful movement. During phase 3, snakes were anesthetized with alfaxalone (30 mg/kg, ICe), and the tactile pressure required to induce purposeful movement was assessed at predetermined times after LRR.

RESULTS Intracoelomic administration of alfaxalone at doses of 10, 20, and 30 mg/kg induced LRR in 0, 5, and 8 snakes, respectively. **For snakes with LRR, median time to LRR following the 30-mg/kg dose (3.8 minutes) was significantly shorter than that following the 20-mg/kg dose (8.3 minutes); median time to return of righting reflex did not differ between the 2 doses.** Mean ± SD tactile pressure that resulted in purposeful movement in unanesthetized snakes was 16.9 ± 14.3 g. When snakes were anesthetized, the mean tactile pressure that resulted in purposeful movement was significantly increased from baseline at 10, 20, and 30 minutes after LRR.

CONCLUSIONS AND CLINICAL RELEVANCE **Results suggested ICe administration of alfaxalone might be effective for anesthetizing garter snakes.**

Key points:

·  Objective: determine the intracoelemic (ICe) dose of alfaxalone required to induce loss of righting reflex (LRR) in garter snakes (Thamnophis sirtalis) and to evaluate the tactile stimulus response in unanesthetized and alfaxalone anesthetized snakes

M&M

·  N=8 adult garter snakes

·  In phase 1  Each snake received each of 3 doses (10, 20, and 30 mg/kg) alfaxalone ICe in a randomized order with a minimum 2 week washout between doses

o   Injection was given in the middle of the caudal third of the coelom

o   Time to loss of right reflex and return to righting reflex were measured

·  In phase 2 the response to tactile stimulus was measured in unanesthetized snakes

o   Increasing pressure until gross pruposefl movement w as elicited

·  In phase 3 the  response of anesthetized snakes to tactile stimulation was measured

o   Each snake given 30 mg/kg alfaxolone Ice

o   Once LRR occurred, repeated test from phase 2, repeated  every 10 minutes ntil gross purposeful movement was elicited

Results

·  LRR not observed in any snake for 10 mg/kg

·  LRR observed in 5/8 snakes with 20 mg/kg and  8/8 for 30 mg/kg

·  Time to LRR was shorter for 30 mg/kg, but time to RRR did not differ significantly

·  RR  did not differ  significantly at any point

·  HR was  lower after LRR  and then got faster again  right before RRR

·  Phase 2: Mean tactile  pressure to  elicit response in unanesthetized snakes was 16.9 +/- 14.3

·  Phase 3: Purposeful movement was not elicited by tactile stimulation testing in any of the 8 snakes at 10 and 20 minutes after LRR

o   Started to elicit  response at  30  minutes  in  some snakes, all snakes  by 50 minutes

o   The mean tactile pressure required to elicit purposeful movement was significantly greater than that at baseline at 10, 20, and 30 minutes after LRR but did not differ significantly from baseline at LRR and at 40, 50, and 60 minutes after LRR.

Discussion

·  30 mg/kg alfaxolone was effective in all snakes

·  Dose was  not  given in the cranial portion of the body because of  vital structures, may have needed a higher dose due to it being in the caudal half

·  HR may  be used to  assess anesthetic depth with this specific drug protocol

·  Anesthetic depth was greatest between 10 and 30 minutes based on lack of response to tactile stimulus

**Evaluation of subcutaneous administration of alfaxalone-midazolam and dexmedetomidine-midazolam for sedation of ball pythons (Python regius).**

Yaw, T.J., Mans, C., Johnson, S., Bunke, L., Doss, G.A. and Sladky, K.K.

JAVMA, 2020;256(5):573-579.

OBJECTIVE To evaluate SC administration of alfaxalone-midazolam and dexmedetomidine-midazolam for sedation of ball pythons (Python regius).

ANIMALS 12 healthy juvenile ball pythons.

**PROCEDURES** In a randomized crossover study, each snake was administered a combination of **alfaxalone (5 mg/kg [2.3 mg/lb]) and midazolam (0.5 mg/kg [0.23 mg/lb])** and a combination of **dexmedetomidine (0.05 mg/kg [0.023 mg/lb]) and midazolam (0.5 mg/kg)**, **SC**, with a washout period of at least 7 days between protocols. Respiratory and heart rates and various reflexes and behaviors were assessed and compared between protocols. Forty-five minutes after protocol administration, sedation was reversed by SC administration of flumazenil (0.05 mg/kg) alone or in combination with atipamezole (0.5 mg/kg; dexmedetomidine-midazolam protocol only). Because of difficulties with visual assessment of respiratory effort after sedative administration, the experiment was repeated for a subset of 3 ball pythons, with plethysmography used to assess respiration.

RESULTS Both protocols induced a similar level of moderate sedation with no adverse effects aside from transient apnea. Cardiopulmonary depression was more profound, but time to recovery after reversal was significantly shorter, for the dexmedetomidine-midazolam protocol than for the alfaxalone-midazolam protocol. Plethysmographic findings were consistent with visual observations and suggested that snakes compensated for a decrease in respiratory rate by increasing tidal volume amplitude.

CONCLUSIONS AND CLINICAL RELEVANCE Results indicated that both protocols induced clinically relevant sedation in ball pythons and should be useful for minor procedures such as venipuncture and diagnostic imaging. However, caution should be used when sedating snakes with compromised cardiopulmonary function.

**Background**

* Alfaxalone: neuroactive synthetic steroid
	+ Enhances neuronal cell membrane chlorine ion transport via interaction with cell surface y-aminobutyric acid A receptors to induce sedation and anesthesia
	+ Apnea and prolonged recovery with high doses in reptiles, reactive to stimulation with low doses

**Key Points**

* Attempted intubation and blood collection at 30 min, reversed at 45 min
* Subset of 3 snakes: respiration evaluated with plethysmography in airtight chamber
* No adverse effects, no tissue damage at injection sites
	+ SC allowed larger volume with comparable induction time to IM
* Both AM and DM: similar depth of sedation, successful intubation and blood draw, HR and RR decreased significantly
* AM:
	+ shorter time to first effect and loss of jaw tone
	+ longer duration of loss of righting reflex (no antagonist)
	+ longer time to recovery
	+ More snakes were reactive to superficial pain stimulation
	+ Majority had spontaneous mouth opening/chewing behavior
* DM:
	+ greater decrease in HR and RR
	+ Increase in tidal volume - possibly compensating for decreased RR
	+ Transient periods of apnea

**Conclusions**

* SC alfaxalone (5 mg/kg) + midazolam (0.5 mg/kg) or dexmedetomidine (0.05 mg/kg) + midazolam (0.5 mg/kg) resulted in sufficient sedation for tracheal intubation and blood sample collection in healthy juvenile ball pythons
	+ Self-limiting apnea
	+ Both protocols induced significant decreases in RR and HR, more profound with DM
	+ DM can be reversed - faster recovery



Bogan Jr, James E., et al. "A RETROSPECTIVE STUDY OF DYSTOCIA IN EASTERN INDIGO SNAKES (DRYMARCHON COUPERI)." *Journal of Zoo and Wildlife Medicine* 52.2 (2021): 618-627.

Abstract: Medical and husbandry records of eastern indigo snakes (EIS) (*Drymarchon couperi*) housed at the Orianne Center for Indigo Conservation (OCIC) were reviewed to determine risk factors for developing dystocia. Thirty-four cases of dystocia were identified out of 104 successful breeding events between 2010 and 2020. The number of breeding events, age, body weight, housing, and selected blood parameters were reviewed for the female EIS successfully bred at OCIC between 2010 and 2020. Categorical data were evaluated with chi-square and the Fisher exact test, and the continuous data were evaluated using analysis of variance. Differences in data were considered statistically significant when *P* < 0.05. There was a significant difference seen between EIS that developed dystocia (EISd) and EIS that did not (EISn) for breeding events, with the **virgin breeding event having more EISd than any other breeding event.** Risk analysis of the data revealed that EIS were 9.28 times more likely to develop dystocia during the virgin breeding event than on subsequent breeding events. **Age and housing were not significantly different between EISd and EISn for each breeding event, but body weight was, as EIS weighing less than 1.5 kg were found to be 4.43 times more likely to develop dystocia.** There was also a significant difference between EISd and EISn in plasma sodium, calcium, ionized calcium, glucose, and albumin. When compared to EISn, **EISd had lower plasma sodium, calcium, ionized calcium, and albumin and higher plasma glucose.** There were also significant differences in the white blood cell differential count, as **EISd had lower basophils and monocytes when compared to EISn. The majority of EISd were managed surgically, and retained eggs were more likely to be located within the right oviduct.** This retrospective study is the first to evaluate potential causes of dystocia in EIS.

Key Points:

* Eastern indigo snake – Large oviparous colubrid, native to SE US.
* Orainne Center for Indigo Conservation established 2010 as a breeding facility for EIS reintroduction efforts.
* EIS unique physiology – Total calcium very high (200+ mg/dL) in normal individuals. Begin breeding in late autumn and continue through winter, with oviposition in spring (unlike other NA colubrids, where breeding is in spring and summer with oviposition late summer).
* Risk for dystocia greatest for snakes < 1500 g and for virgin EIS. Virgin higher risk regardless of BW.
* Total calcium, iCa, sodium lower in dystocia snakes; plasma glucose and albumin higher in dystocia snakes.
* Relative basophil, absolute basophil, absolute monocytes lower in dystocia snakes.
* Retained eggs most frequent in right oviduct. Right oviduct is longer.
* Majority of intraoperative oviductal cultures yielded gram negative bacteria.
* It has been shown in other studies that EIS housed outdoors have higher plasma vit D and total Ca vs those housed indoors, may be a factor in preventing dystocia.
* A single case of preovulatory follicular stasis in this study, uncommon. Ovariectomy performed, did well.
* Obstructive ophidian dystocia – Abnormally large eggs, oviductal abnormalities (torsion, chronic salpingitis with egg adhesions), or organ enlargement i.e. renomegaly.
* Nonobstructive ophidian dystocia – Most commonly due to calcium deficiency, other metabolic issues/dehydration. Medical management with oxytocin is unrewarding and not recommended.
* Majority of EIS with dystocia in this study had undergone partial oviposition prior to developing dystocia.
	+ Fluids, warm water soaks helped in some cases; others surgical.
* Recommendations:
	+ Ensure proper hydration, consider 0.9% NaCl for fluids since snakes in this study were hyponatremic.
	+ If plasma iCa on i-STAT is less than the reported EIS normal values, administering parenteral calcium may be beneficial.
	+ Preservation of a retained egg should not be the focus for treatment as all eggs were shown to be infertile.
	+ Avoid percutaneous aspiration of a retained egg, as ectopic ova have been described. Ovocentesis should only be performed when eggs are visible or digitally palpable through the cloaca.

"Bacteria Associated with Clinically Suspected Respiratory Disease in Snakes and Effective Antimicrobial Treatment Options."

*Journal of Herpetological Medicine and Surgery* 30.4 (2020): 254-260.

Captive snakes often suffer from pneumonia. Factors contributing to this problem include husbandry issues, nutrition, and hygiene. Infectious agents are particularly important, and bacteria can be primary or secondary drivers of disease processes. If these are not treated, they can lead to lifethreatening problems. Bacteria were isolated from the lower respiratory tracts of 25 snakes with clinical signs of pneumonia. Antibiograms were made for the isolated bacteria against antibiotics commonly used to treat respiratory disease in small animals as well as macrolides and phenicols used to treat respiratory disease in cattle. Three hundred fifty snakes with clinical respiratory disease were then treated with one of the macrolides or the phenicol and monitored by bioassay for antibiotic activity in the blood and for clinical recovery. A total of 47 different bacteria, all Gram negative, were isolated from the tracheal washes of the 25 snakes. The highest sensitivity rates (.80%) were found against enrofloxacin and marbofloxacin, trimethoprim/sulfamethoxazole, the macrolides tularthromycin, tilmicosin, tildipirosin, and gamithromycin, and the phenicol flurofenicol. Of the snakes treated with tularthromycin, tilmicosin, gamithromycin, tildipirosin, or florfenicol, 89.4% recovered clinically within 2–3 wk of treatment.

Intro

* Respiratory system of the snake is quite variable
* Left lung is reduced in size or absent in many species - boas and pythons have both right and left lung though right is larger
* Pneumonia is common in captive snakes
* Based on the importance of bacterial infections in pneumonia of snakes, as well as the increasing importance of antimicrobial resistance, this study was carried out to evaluate bacteria associated with respiratory disease in boas and pythons presented to a veterinary clinic in Germany and to help evaluate effective antibiotics that could be used for their treatment.

M&M

* 25 snakes with clinical signs suggestive of pneumonia, including dyspnea and hissing or crackling sounds during respiration, were examined for bacteria (all boas and pythons)
* Lung washes performed - culture and sensitivity
* Clinical trials - 5 antibiotics were used in 350 snakes suffering from respiratory disease
	+ The snakes belonged to the families Boidae, Pythonidae, Colubridae, Elapidae, and Viperidae.
	+ Gamithromycin, tildipirosin, tilmicosin, tulathromycin and florfenicol
	+ All client owned animals, diagnostic testing not routinely performed due to finances. Snakes were generally treated for 14 days. If no improvement, culture and sensitivity was performed

Results and discussion

* 47 different bacteria isolated from the initial 25 snakes
* **All of the isolated bacteria were Gram negative, and most (32, 68.1%) were members of the family Enterobacteriaceae.**
* Bacteria in the genera Citrobacter (73), Pseudomonas (63), Klebsiella (63), Enterobacter (53), and Proteus (53) were most commonly isolated
* Differentiation between the normal bacterial flora and pathogenic bacteria associated with specific clinical disease is very challenging in reptile medicine, because the normal bacterial flora is largely made up of facultative pathogens
* Less than 50% of the isolated bacteria were sensitive to ampicillin, amoxicillin, amoxicillin–clavulanic acid, cephalexin, clindamycin, tetracycline, oxytetracycline, erythromycin, metronidazole, penicillin, and rifampicin. Between 50 and 75% were sensitive to doxycycline, and over 75% were sensitive to enrofloxacin, marbofloxacin, and trimethoprim/sulfamethoxazole. The detected sensitivity rates for the macrolide and phenicol antibiotics tested were tildipirosin 72.3%, gamithromycin 85.1%, tilmicosin 80.9%, tulathromycin 83.0%, and florfenicol 93.6%.
* Clinical trials - The clinical signs resolved completely within 2 or 3 wk in 313 (89.4%) of the 350 animals treated.
	+ Success rates between treatments with each of the five antibiotics used on these animals appeared comparable

* **Takeaway:** This study shows that the antibiotics gamithromycin, tildipirosin, tilmicosin, tulathromycin, and florfenicol can be efficacious against bacteria isolated from the trachea and lungs of snakes with respiratory disease, as well as in treating snakes with clinical signs of respiratory disease.

*AJVR* 2021 82(1):11-21

[**Respiratory and antinociceptive effects of dexmedetomidine and doxapram in ball pythons (*Python regius*)**](https://doi.org/10.2460/ajvr.82.1.11)

Karklus AA, Sladky KK, Johnson SM

**ABSTRACT:**

**Objective:**To determine the effects of dexmedetomidine, doxapram, and dexmedetomidine plus doxapram on ventilation (VE), breath frequency, and tidal volume (VT) in ball pythons (*Python regius*) and of doxapram on the thermal antinociceptive efficacy of dexmedetomidine.

**Animals:**14 ball pythons.

**Procedures:**Respiratory effects of dexmedetomidine and doxapram were assessed with whole-body, closed-chamber plethysmography, which allowed for estimates of VE and VT. In the first experiment of this study with a complete crossover design, snakes were injected, SC, with saline (0.9% NaCl) solution, dexmedetomidine (0.1 mg/kg), doxapram (10 mg/kg), or dexmedetomidine and doxapram, and breath frequency, VE, and VT were measured before and every 30 minutes thereafter, through 240 minutes. In the second experiment, antinociceptive efficacy of saline solution, dexmedetomidine, and dexmedetomidine plus doxapram was assessed by measuring thermal withdrawal latencies before and 60 minutes after SC injection.

**Results:**Dexmedetomidine significantly decreased breath frequency and increased VT but did not affect VE at all time points, compared with baseline. Doxapram significantly increased VE, breath frequency, and VT at 60 minutes after injection, compared with saline solution. The combination of dexmedetomidine and doxapram, compared with dexmedetomidine alone, significantly increased VE at 30 and 60 minutes after injection and did not affect breath frequency and VT at all time points. Thermal withdrawal latencies significantly increased when snakes received dexmedetomidine or dexmedetomidine plus doxapram, versus saline solution.

**Conclusions and clinical relevance:**Concurrent administration of doxapram may mitigate the dexmedetomidine-induced reduction of breathing frequency without disrupting thermal antinociceptive efficacy in ball pythons

**Key Points:**

* Opioids are effective in turtles and lizards but inconsistently effective in snakes
* In the few studieswith reptiles, including snakes, NSAIDs have minimal efficacy
* Dexmedetomidine provides thermal antinociception for at least 8 hours in ball pythons
	+ However, it also significantly decreases breath frequency
	+ α2 agonists acting at brainstem and peripheral α2-adrenoceptorscause inhibition of breathing in mammals, amphibians, and reptiles
* Doxapram is a K+ channel blocker that acts on central respiratory centers and peripheral chemoreceptors to stimulate breathing in a dose-dependent manner
	+ It is associated with decreased cerebral blood flow in dogs and goatsand increased cardiac work in dogs, which may limit its usefulness to reptiles
	+ In mammalian studies, the effects of single doses are short-lived (5-15 min)
	+ However, it has a longer duration of action in alligators and snakes because of the lower metabolic rate of reptiles and subsequent slower drug metabolism

**TLDR:** Dexmedetomidine is an effective analgesic in ball pythons but decreases respiratory rate. Doxapram may mitigate this without affecting analgesia

**Related Articles**

Sladky KK. Analgesia. In: Mader DR, Divers S, eds. *Current therapy in reptile medicine and surgery*. 3rd ed. St Louis: Elsevier-Saunders, 2014;217 228

Sladky KK, Mans C. Analgesia. In: Divers SJ, Stahl SJ, eds. *Mader's reptile and amphibian medicine and surgery*. St Louis: Elsevier, 2019;465 474

*JAVMA* 2020 257(9):945-949

[**Comparison of isoflurane, sevoflurane, and desflurane as inhalant anesthetics in prairie rattlesnakes (*Crotalus viridis*)**](https://doi.org/10.2460/javma.257.9.945)

Kane LP, Chinnadurai SK, Vivirito K, Strahl-Heldreth D, Allender MC

**ABSTRACT:**

**Objective:**To characterize induction and recovery characteristics of 3 commonly used inhalant anesthetics in prairie rattlesnakes (*Crotalus viridis*): isoflurane, sevoflurane, and desflurane.

**Animals:**12 healthy adult prairie rattlesnakes.

**Procedures:**In a randomized crossover design, snakes underwent anesthetic induction with 5% isoflurane, 8% sevoflurane, or 18% desflurane, with a washout period of ≥ 7 days between anesthetic events. Anesthetic depth parameters were recorded throughout induction and recovery, including time to loss and return of righting reflex, muscle tone, ability to intubate, response to pressure, and time to return to spontaneous respiration. Every 5 minutes throughout the anesthetic procedures, heart rate, respiratory rate, and percentage expired anesthetic gas were recorded.

**Results:**No snakes died during the study. Sevoflurane anesthesia resulted in anesthetic gas avoidance behavior in snakes during induction and had the significantly longest recovery time to extubation and time to return of pressure response, compared with the other inhalant anesthetics. Anesthesia with isoflurane resulted in a significantly longer time to return of righting reflex, compared with sevoflurane or desflurane. No significant difference was noted in time to loss of pressure response among the 3 anesthetic gases. Desflurane anesthesia resulted in the significantly quickest loss of righting reflex among the anesthetic protocols; despite this, 4 of 12 desflurane anesthetized snakes did not achieve an anesthetic plane deep enough for intubation.

**Conclusions and clinical relevance:**Isoflurane and sevoflurane, but not desflurane, inhalation anesthesia resulted in consistent and predictable loss of righting reflex and induction of anesthesia deep enough to allow intubation in snakes.

**Key Points:**

* Anesthetic depth in reptiles is frequently evaluated by loss or return of righting reflex, muscle relaxation, presence or absence of corneal reflex, or pressure response with forceps or a needle applied to the tail or foot
* Previous inhalant anesthetic comparisons in reptiles have focused primarily on MAC
	+ Determination of MAC requires a prolonged equilibration period prior to restimulation when gross purposeful movements are observed
	+ In Dumeril monitors anesthetized with isoflurane, the MAC is similar to that in mammals but is lower than that in other reptiles, such as radiated rat snakes, green iguanas, or desert iguanas
	+ Evaluation of MAC of sevoflurane, isoflurane, and desflurane in green iguanas revealed decreases in anesthetic gas concentrations over time, emphasizing the unique reptilian cardiorespiratory system and the necessity for species-specific inhalant anesthetic evaluation
* A comparison of isoflurane and sevoflurane in colubrid snakes produced profound respiratory and cardiac depression with both anesthetics
	+ In contrast, heart rate did not differ under anesthesia with sevoflurane and isoflurane in green iguanas or in desert tortoises anesthetized with sevoflurane
	+ Similarly in the present study, a few snakes anesthetized with isoflurane and sevoflurane required positive-pressure ventilation until spontaneous respiration returned and no heart rate differences were found between the anesthetic gases
* Several differences were detected in induction and recovery events for the inhalant anesthetics used in the present study:
	+ Isoflurane produced the longest time to return of righting reflex
	+ Sevoflurane had the longest time to return of pressure response
	+ Desflurane had the shortest time to intubation and fastest time to loss of righting reflex
* Interestingly, a comparison of isoflurane, sevoflurane, and desflurane in green iguanas noted no significant differences for any induction or recovery events for any of the inhalation agents
* In chelonians and other reptilian species, inhalation anesthesia is challenging as a result of breath holding and intracardiac right-to-left shunting
	+ Reptiles have a lower cardiac index than mammals, which may slow movement of anesthetic gas; however, they also have higher alveolar anesthetic partial pressures, resulting in a faster induction of anesthesia
	+ The right-to-left shunting in non-crocodilian reptiles reduces the effective cardiac output for distribution of anesthetic-rich blood, and movement of inhaled anesthetics from the lungs to the blood can be impeded by large ventilation-perfusion mismatches
* Core body temperature of snakes could change the blood-gas partition coefficient of inhaled anesthetics if it is below their optimal temperature zone
	+ Snakes in the present study were maintained at the same temperature for the duration of the study, eliminating temperature as a difference in inhalant gas recovery
* Semmes-Weinstein monofilament threads may be a useful, noninvasive method for assessment of pressure response in both venomous and nonvenomous reptilian species
	+ Monofilament threads were also used successfully for assessment of anesthetic depth in garter snakes anesthetized with intracoelomic administration of alfaxalone

**TLDR:**

* Isoflurane and sevoflurane in prairie rattlesnakes provided effective anesthesia for quick, nonpainful procedures
* The use of desflurane in rattlesnakes, and potentially other vipers, is not recommended

**Related Articles**

Strahl-Heldreth DE, Clark-Price SC, Keating SCJ, et al. Effect of intracoelomic administration of alfaxalone on the righting reflex and tactile stimulus response of common garter snakes (*Thamnophis sirtalis*). *Am J Vet Res* 2019;80:144–151