Untangling the Intricacies of Companion Reptile Nutrition, Associated Diseases, and Client Compliance

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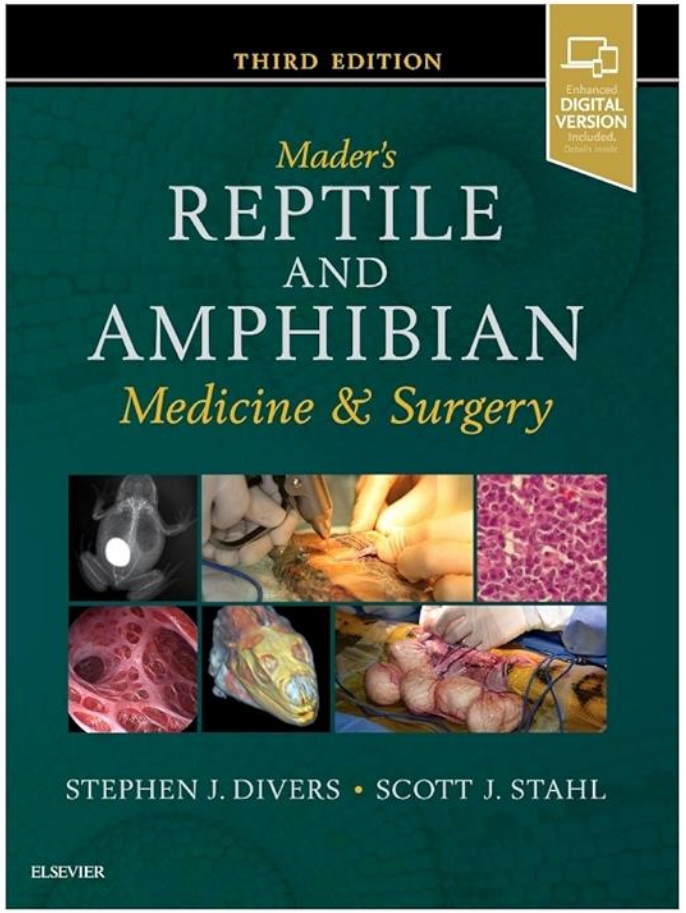
Board-Certified Specialist in Zoological Medicine®

Special thanks to Joanna Hitzschky, DVM, MS, DACZM

Who am I?

- University of Illinois Urbana-Champaign – Vet school
- Milwaukee Emergency Center for Animals – ER-only internship
- Louisiana State University CVM – zoological medicine internship
- University of California-Davis – ACZM-approved residency (zoological companion animal focus)
- VCA South Shore (Weymouth) Animal Hospital
- CCVS!



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Outline

- Introduction
- Metabolism Basics
- Macro- and Micronutrients
- Feeding Strategies
- Feed Items
- Nutritional Diseases
- Nutritional Support
- Increasing Client Compliance
- Q&A

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Abbreviations

- Calcium = Ca
- Phosphorus = P
- Calcium:phosphorus ratio = Ca:P ratio
- Ultraviolet B = UVB
- Preferred Optimal Temperature Zone = POTZ

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Introduction & Metabolism Basics

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Introduction to Reptile Nutrition

- Nutrition requirements are species specific
- Current season or hormone concentrations play a role
  - Brumation
  - Reproduction
- Utilization of feedstuffs is dependent on environmental husbandry
  - Temperature
  - Humidity
- Compared to free-ranging counterparts, decreased insect variability available in human care

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DETAILED HUSBANDRY ASSESSMENT IS ESSENTIAL

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Metabolism

- 1/10th energy requirements of mammals
- POTZ important for utilization of feedstuffs & immune function
  - Terrestrial reptiles typically stenothermal
  - Provide thermal gradient in enclosure
- Raise temperatures towards higher end of POTZ when diseased

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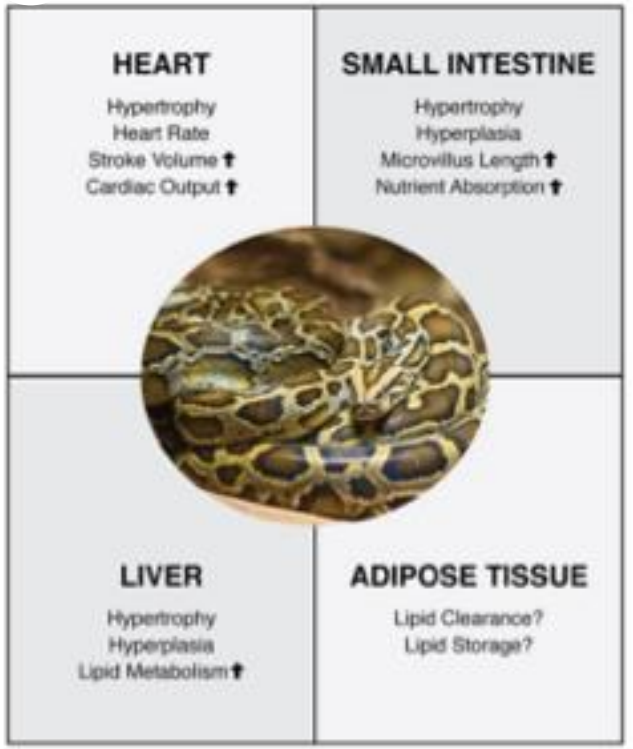
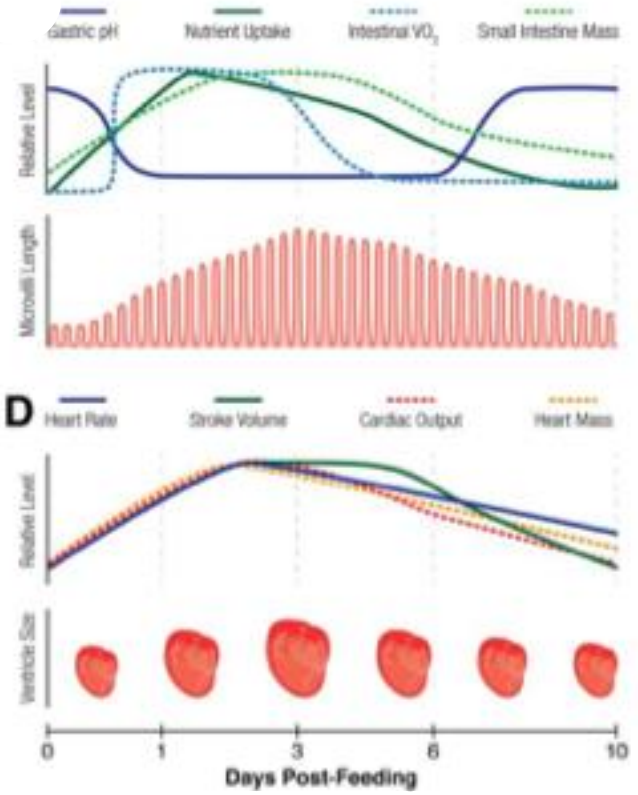
Specific Dynamic Action

- Increased metabolism in response to feed intake
  - Whole prey items
- Ingestion of amino acids in *Python regius* & *Python molurus*
  - Increased O2 consumption
  - Increased heart rate
  - Increased cardiac size





Journal of Muscle Research and Cell Motility
https://doi.org/10.1007/s10974-022-09632-2

REVIEW

Utility of the burmese Python as a model for studying plasticity of extreme physiological systems

Yuxiao Tan[1] · Thomas G. Martin[1] · Brooke C. Harrison[1] · Leslie A. Leinwand[1]

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Macro- & Micronutrients

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Water

- Most important nutrient
- Larger tolerance for dehydration compared to mammals & avian species
- Aid in conservation of total body water through higher humidity in enclosure
  - Species specific
- Terrestrial reptiles
  - Primary nitrogenous waste product = uric acid (uricotelic)
  - Conserve water at renal tubule
- Aquatic reptiles
  - Larger percentage of nitrogenous waste as ammonia (ammoniotelic) or urea (ureotelic)

Water Sources

- Dietary
  - Greens
  - Prey items
- Metabolic water
- Environmental
  - Water available always
  - Bowl – ensure animal will be able to access and escape from bowl
  - Misters
  - Drippers

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Water Sources –Soaking

- Warm water
  - Heating element, reheat water
- Dictate length of soak and frequency of soak
- Cloacal absorption?
  - Bearded dragons administered furosemide
    - Actively drink water when soaked
    - Increase in body weight when drinking or soaking
- Voluntary or mandatory via caretaker
- Ensure animal can keep its head above water
  - Water depth, tub angle for dull patients

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Calcium

- Total body calcium distribution
  - > 99% bone matrix (calcium hydroxyapatite)
  - < 1% ionized calcium, bound to albumen or other proteins
- Ionized Ca = most accurate evaluation of calcium status

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Calcium – Dietary Sources

- Leafy greens – chelated calcium
  - Best calcium bioavailability
  - Research study on ground snake hatchling supplements
- Carnivorous species consuming whole prey do not require additional calcium supplementation

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Calcium – Dietary Sources (con't.)

- Supplementation
  - Independent of multivitamin supplement
  - Phosphorus and vitamin D ***free*** powder
  - Calcium carbonate – 40% elemental availability
  - Calcium citrate – 21% elemental availability

Type of Calcium Can Be Important as not All are Absorbed Equally; Calcium Carbonate and Calcium Citrate are Best Absorbed

Ca Salt (1 gram)	Elemental Calcium (mg)	Percent Calcium Salt Absorbed or Elemental Ca Available
Ca carbonate	400	40%
Ca citrate	211	21%
Ca lactate	130	13%
Ca gluconate	93	9.3%
Ca glubionate	66	6.6%

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Calcium – Homeostasis

- Vitamin D
  - Increases Ca absorption in the gut
  - Increases Ca resorption of the bone
  - Increases Ca resorption in kidney
  - Decreases P secretion in the kidney
- Parathyroid hormone
- Calcitonin
- Ideal Ca:P = 1.5-2:1

Hormone	Ca	P
Vitamin D	↑	↑
Parathyroid Hormone (PTH)	↑	↓
Calcitonin	↓	↓

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Vitamin D

- Fat soluble vitamin
- Risk of toxicity if over-supplemented
- Sources
  - Plants
  - Animals or by-products
  - Nutrition supplements (1-2x/month)
  - +/- UVB irradiation
- Providing adequate UVB irradiation decreases amount of dietary vitamin D required
  - Ensure UVB bulbs are being replaced routinely (manufacturers recommendation)

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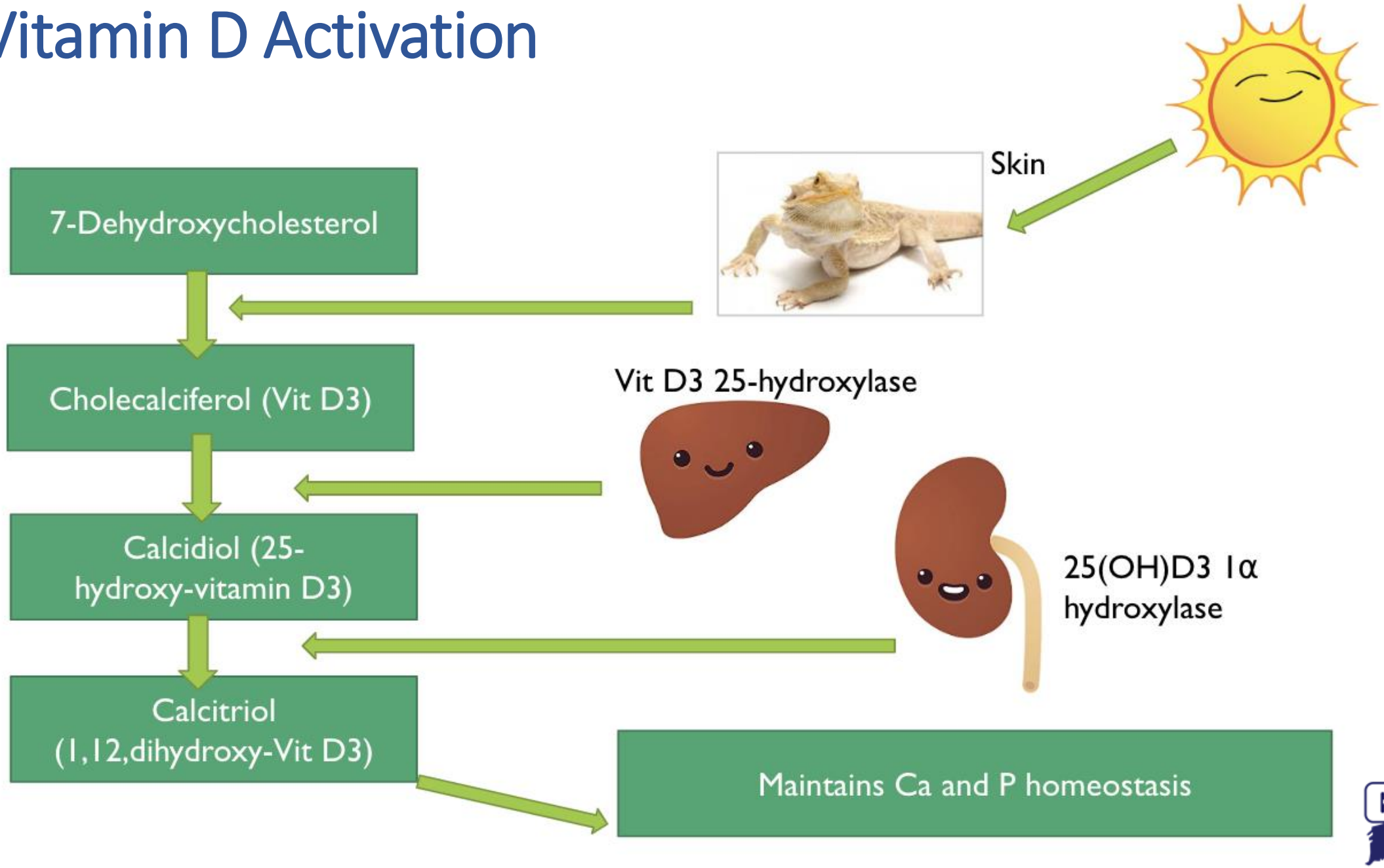
Vitamin D Activation



UVB Irradiation

- Considered essential for almost all species studied
- Important for various physiological functions
  - Immune system, disinfection
  - Improvement of the skin barrier
  - Upregulation of melanin synthesis
- Most species studied utilize UVB
  - Based on an increase in calcidiol (25-OH-Vit D) synthesis
  - Includes nocturnal species
  - Ball pythons?
- Cutaneous conversion 7-dehydroxycholesterol --> cholecalciferol
  - Appropriate temperature
  - UVB 290-315 nm

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UVB Sources & Considerations

- Types of lightbulbs
  - Fluorescent
  - Metal halide
  - Mercury vapor
  - LED
- Use solarmeter to measure UVB irradiation at level of basking site
  - Discard bulb when level < 70% of original
- Provide direct access – some materials block UV light
  - Glass – close to 100%
  - Plastic – close to 100%
  - Wire mesh screens – best option – 30-50%
  - Not recommended to provide direct access – risk of thermal burns

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UVB Associated Risks

- Hypomelanistic or albino morphs
  - May require lower UVB
- Keratitis
- Possible cutaneous neoplasia

https://www.magonlinelibrary.com/doi/abs/10.12968/coan.2014.19.7.379

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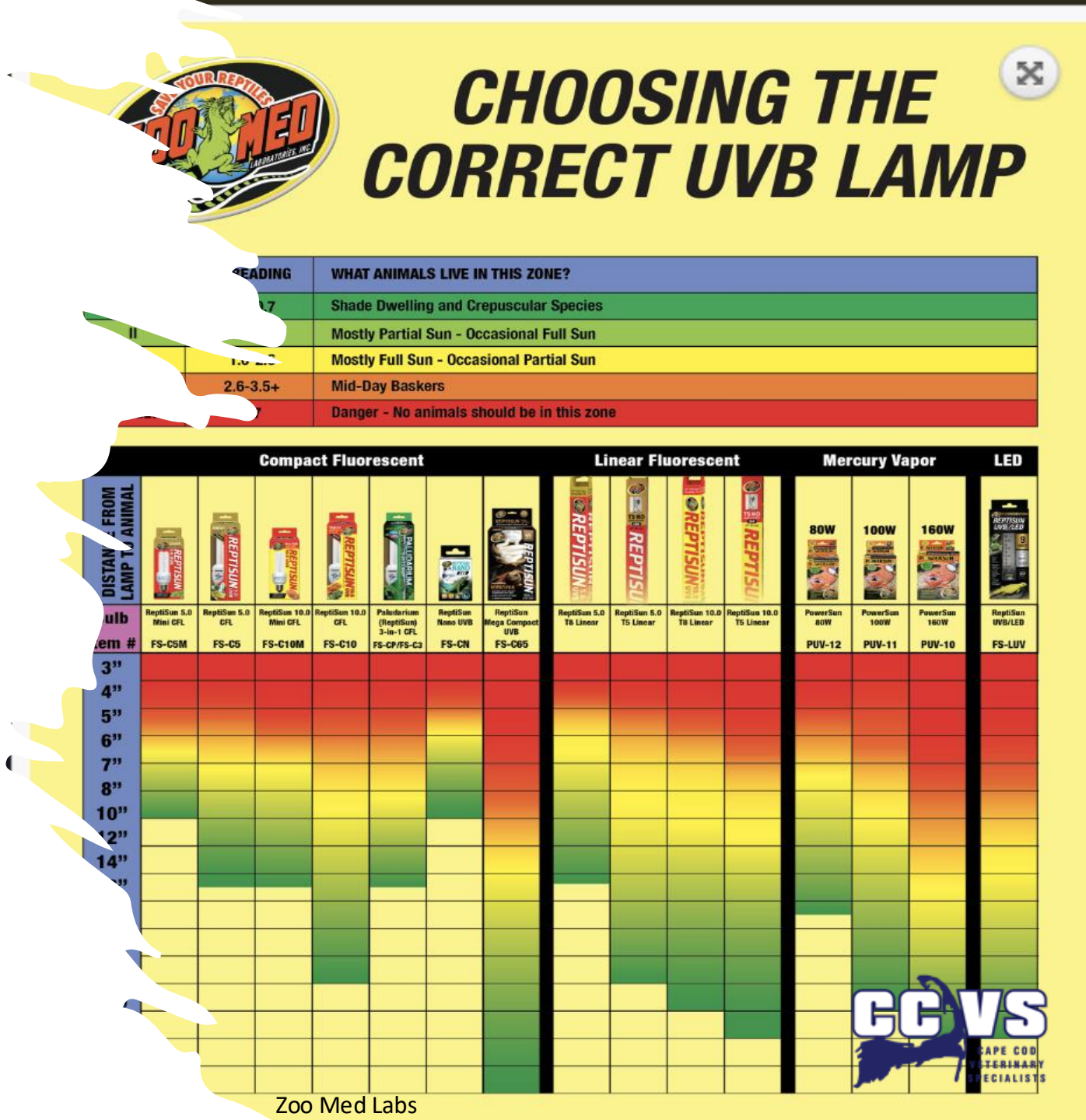
UVB Sources & Considerations

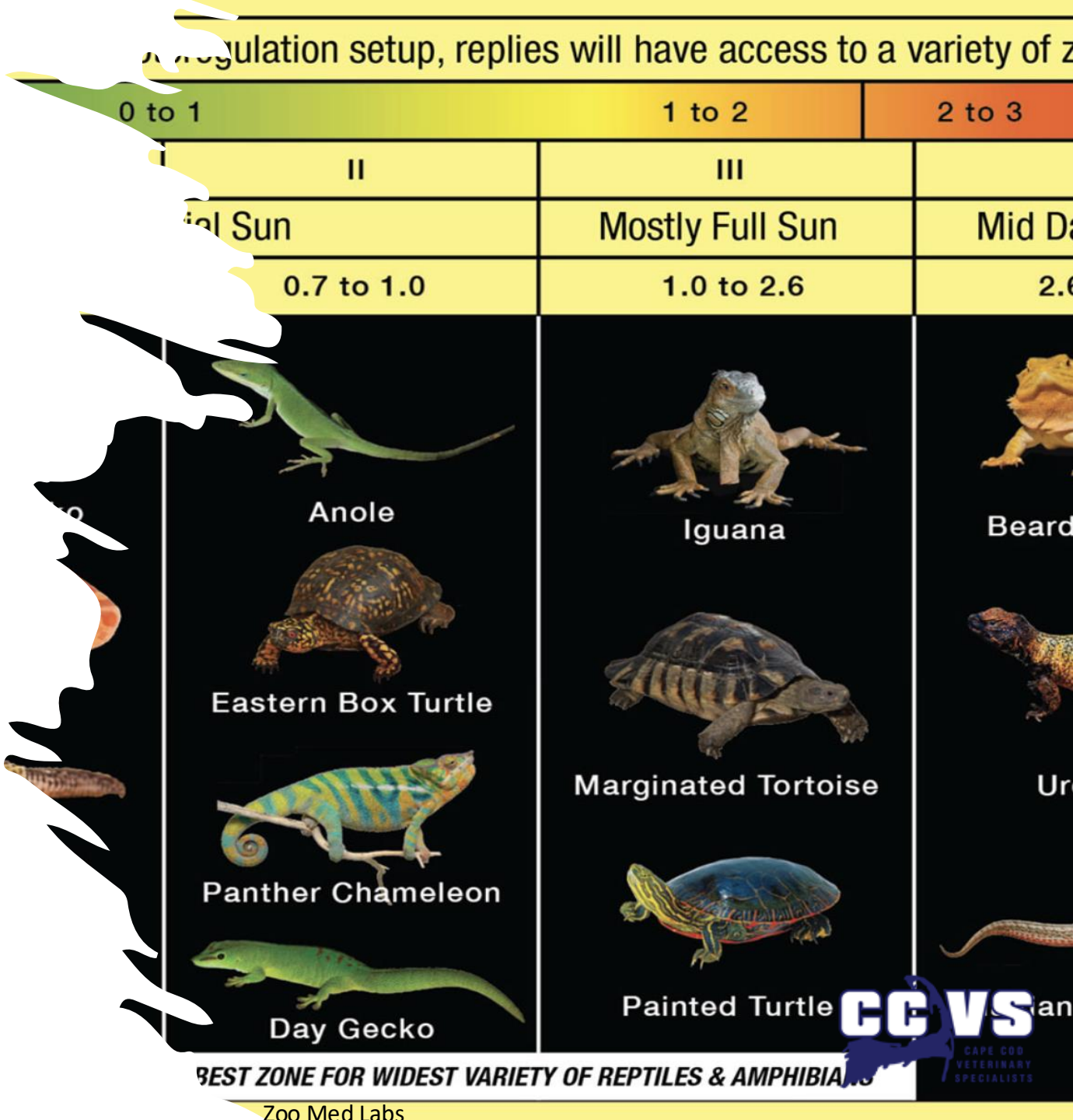
Follow manufacturer recommendations for distance from the animal



Zoo Med Labs

UVB Sources & Considerations

Follow manufacturer recommendations for distance from the animal



Vitamin A

- Fat-soluble vitamin – potential for over-supplementation and toxicity
- Important for many physiological functions
  - Epithelial cell health
  - Immune system function
  - Reproduction
  - Embryonic development
  - Bone metabolism
  - Hematopoiesis
  - Vision

https://tofubud.com/blogs/tips/vegan-sources-of-vitamin-a

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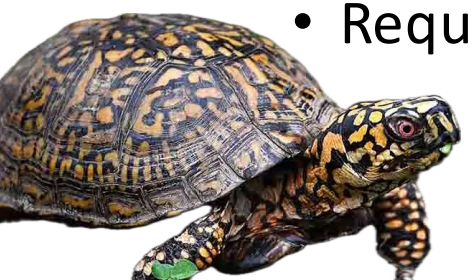
Vitamin A Synthesis & Utilization

- Carnivores consuming whole-prey do not develop deficiencies
  - Liver of prey items contain adequate stores
- Herbivores are capable of synthesizing vitamin A
  - Retinol and retinoic acid
- Species with higher risk of hypovitaminosis A
  - Emydidae turtles
  - Insectivorous squamates: chameleonidae, fat-tailed geckos, leopard geckos (?)
  - Controversial ability to convert β carotene to vitamin A
  - Require pre-formed vitamin A in diet



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Vitamin A Sources

- Ideal ratio of vitamin A : D : E = 100:10:1
- Ensure the supplement contains the proper form: β carotene vs pre-formed vitamin A

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Feeding Strategies

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Carnivores

- Protein (25-60%), fat (30-60%), carbohydrate (<10%)
- All snakes
- Lizards: monitors, tegus
- Chelonians: many turtles
- Crocodilians

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Insectivores

- Many lizards, some turtles
- Many obligate carnivore adults are insectivores as juveniles

Omnivores

- Protein 15-40%, fat 5-40%, carbohydrate 20-75%
- Protein: carbohydrate proportion changes with age

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Herbivores

- Protein 15-35%, fat < 10%, carbohydrate 50-75% (fiber = 15-40%)
- Hindgut fermentation
- All require UVB light
- Chelonians
- Certain lizard species

Green Iguana GI Tract

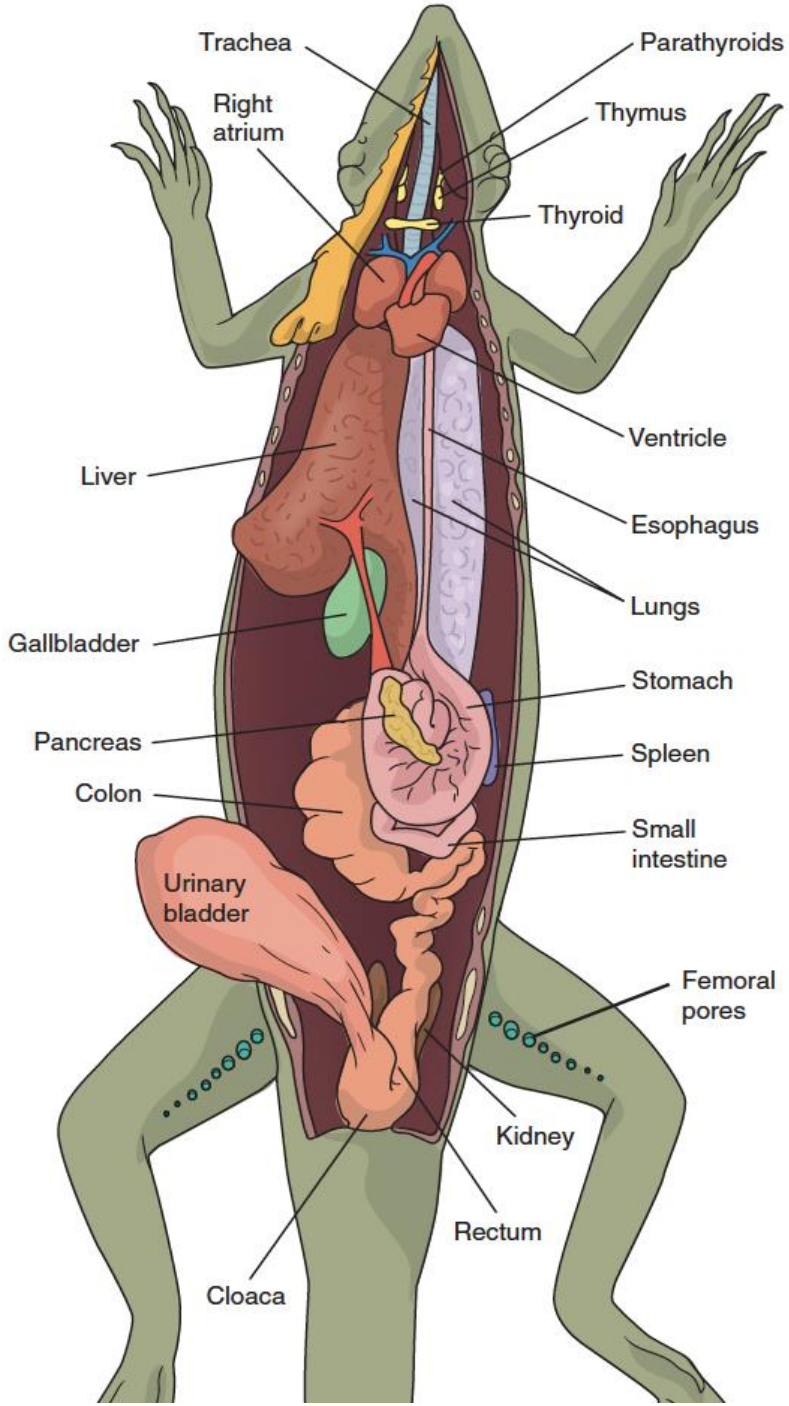

Figure 9.5 Mader 2019

Feed Items

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Vegetables

- Uncooked leafy greens
- Minimize goitrogenic substances
- Minimize oxalic acid

oxalates

goitrogens

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Hay & Flowers

- Hay
  - Timothy hay
  - Orchard grass
  - Alfalfa hay
- Flowers

DANDELION

ROSE

TIMOTHY

ORCHARD

ALFALFA

HIBISCUS

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Toxic Plants

- Ramson (*Allium ursinum)*
- Rhododendrons (Rhododendron spp.)
  - Grayanotoxins --> flaccid paresis
- Oleanders (*Nerium oleander*)
- Chinaberry trees (*Melia azedarach*)
- Tree tobacco (*Nicotiana glauca*)
- Toadstools (*Agaricomycetes*)

RAMSON

AZALEA RHODODENDRON

OLEANDER

CHINABERRY

TOBACCO

TOADSTOOL

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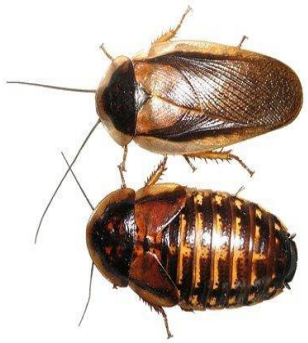
Insects

- Crickets, Dubia roaches
- Hornworms, mealworms, waxworms, superworms, earthworms
- Flies, black soldier fly larvae
- Nutrient analysis: larval vs adult life stages
- Normally deficient in calcium and Vitamins B, A, D, E
- Normally excessive in phosphorus



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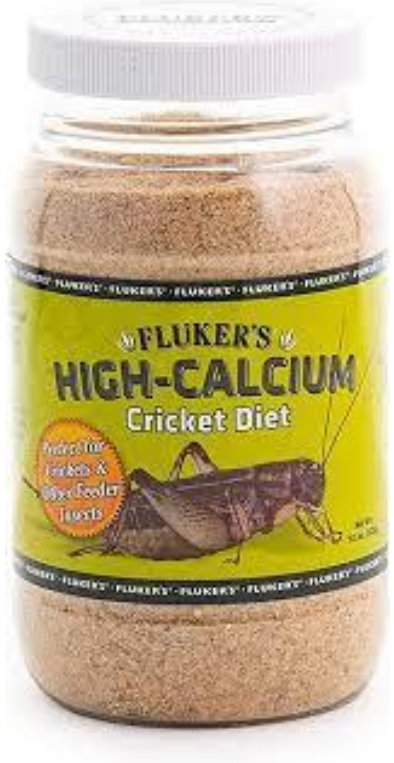
Dusting & Gut-Loading

- Dusting
  - Immediately before feeding
- Gut-loading
  - Commercial forms
  - 24-48 hours before feeding
- Ensure insects have water available



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Gut Loading Resources

Digestibility of black soldier fly larvae (*Hermetia illucens*) fed to leopard geckos (*Eublepharis macularius*) KL Boykin, RT Carter, K Butler-Perez, CQ Buck, JW Peters, KE Rockwell, ... PLoS One 15 (5), e0232496	25	2020	←
Evaluation of vitamin A gut loading in black soldier fly larvae (*Hermetia illucens*) KL Boykin, MA Mitchell Zoo biology 40 (2), 142-149	22	2021	←
Evaluating the efficacy of alfaxalone in corn snakes (Pantherophis guttatus) K Rockwell, K Boykin, J Padlo, C Ford, S Aschebrock, M Mitchell Veterinary anaesthesia and analgesia 48 (3), 364-371	15	2021	
Using a commercial gut loading diet to create a positive calcium to phosphorus ratio in mealworms (Tenebrio molitor) K Boykin, A Bitter, MA Mitchell Journal of Herpetological Medicine and Surgery 31 (4), 302-306	6	2021	←
Determining the effects of serial injections of pregnant mare serum gonadotropin on plasma testosterone concentrations, testicular dynamics, and semen production in leopard … AK Mason, J Lee, SM Perry, KL Boykin, F Del Piero, M Lierz, MA Mitchell Animals 11 (9), 2477	6	2021	
Preliminary evaluation of a novel insect-based sausage diet for juvenile corn snakes (Pantherophis guttatus) KL Boykin, K Butler-Perez, CQ Buck, JW Peters, MA Mitchell Journal of Herpetological Medicine and Surgery 30 (3), 129-136	6	2020	←
Measuring the effects of a single dose of human chorionic gonadotropin (hCG) on plasma testosterone concentrations in leopard geckos (Eublepharis macularius) AK Mason, SM Perry, K Boykin, MA Mitchell Journal of Herpetological Medicine and Surgery 31 (3), 197-203	5	2021	
The value of black soldier fly larvae (Hermetia illucens) as a food source: a review K Boykin, MA Mitchell Journal of Herpetological Medicine and Surgery 31 (1), 3-11	5	2021	←

Gut Loading Resources (con't.)

Characterizing the Roles of Life Stage and Season on the Prevalence of Select Viral Pathogens in *Acheta domesticus* Crickets on a Commercial Cricket Farm in the … KL Boykin, A Bitter, ZN Lex, J Tuminello, MA Mitchell Veterinary Sciences 12 (3), 191	3	2025	←
What veterinarians need to know about the newly-emerging field of insects-as-food-and-feed KL Boykin, MA Mitchell Veterinary Sciences 12 (1), 12	3	2024	←
Ocular findings in a group of healthy captive leopard geckos P Camacho-Luna, C Alling, K Boykin, CC Liu, RT Carter, AC Lewin Veterinary ophthalmology 23 (3), 489-496	3	2020	
Assessing the nutritional value of black soldier fly larvae (Hermetia illucens) used for reptile foods KL Boykin Louisiana State University and Agricultural & Mechanical College	3	2019	←
Effect of Commercial Diets on the Nutritional Value and Mortality Rates of Dubia Roaches (Blaptica dubia) E Barras, KL Boykin, MG Aguilar, Z Lex, A Bitter, MA Mitchell Journal of Herpetological Medicine and Surgery 35 (3), 176-191	1	2025	←
A Preliminary Investigation of the Gastrointestinal Bacterial Microbiomes of Barred Owls (*Strix varia*) Admitted to a Wildlife Hospital H Rhim, MG Aguilar, KL Boykin, K Zapanta, JA Krumbeck, MA Mitchell Animals 15 (11), 1643	1	2025	
Dubia roaches (Blaptica dubia): food for insectivores made better by gut loading with a high calcium commercial diet E Barras, K Boykin, G Aguilar, Z Lex, A Bitter, MA Mitchell Journal of Herpetological Medicine and Surgery 34 (3), 184-192	1	2024	←
Characterizing the roles of bacterial and viral agents in house crickets (Acheta domesticus) at commercial rearing facilities in the United States KL Boykin	1	2024	←

Pelleted and Manufactured Diets

- Contain all nutrients
- 25-50% of herbivore diet
- Challenge – enticing consumption by animal
- Check product label – not all pellets are created equal

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Nutritional Diseases

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Nutritional Secondary Hyperparathyroidism (NSHP) - Introduction

- **Most common nutritional disease of reptiles in captivity**
- Signalment
  - Typically young animals
  - Tortoises, leopard geckos, bearded dragons, iguanas
  - Animals provided whole prey typically unaffected (eg: snakes)
- Etiology
  - Inadequate – dietary Ca, vitamin D3, UVB
  - Unbalanced – Ca:P ratio
  - Combination thereof

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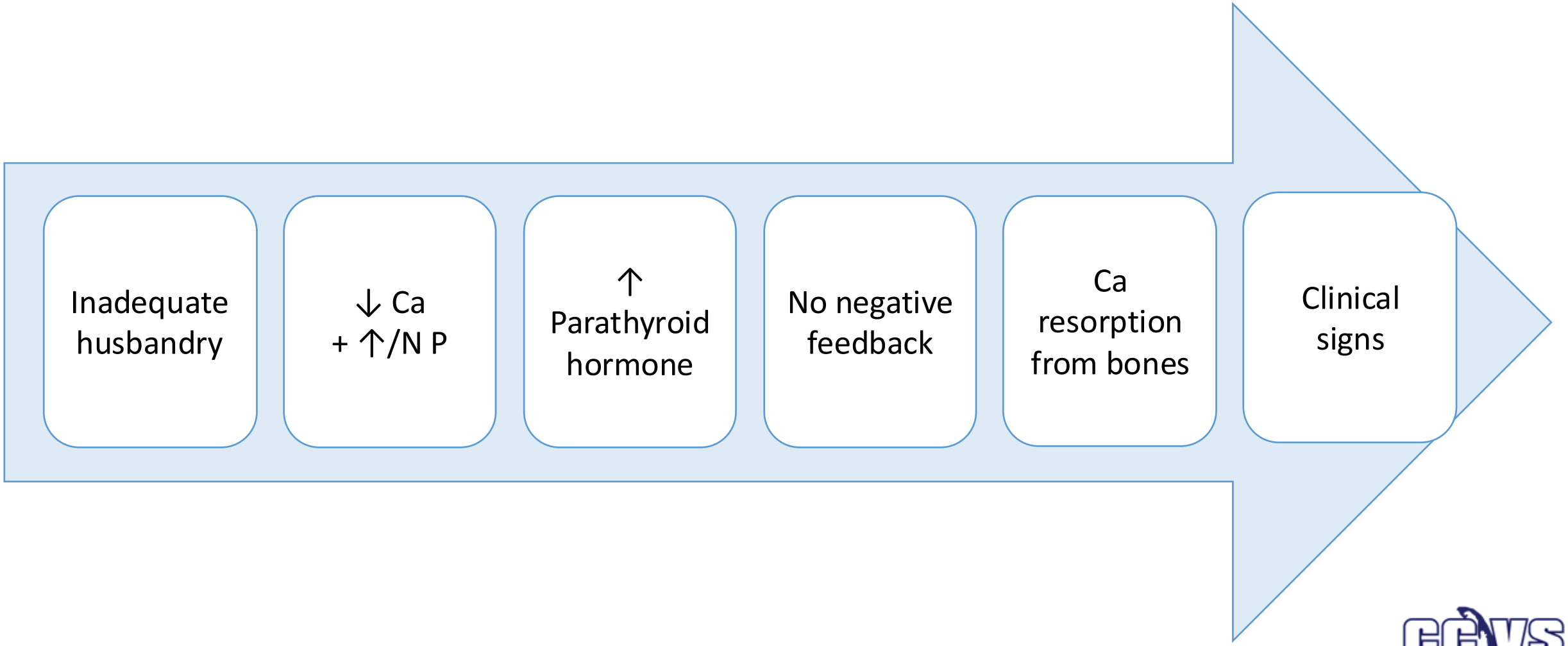
NSHP – Pathophysiology



NSHP – Mild and Moderate Clinical Signs

Mild

- Wide, varied, nonspecific
- Lethargy, weakness
- Anorexia, hyporexia
- Lack of growth

8 yr MI red-eared slider
< 250 grams

Moderate

- Paresis, plegia
  - Splayed legs in chelonians
- Muscle fasciculations
- Gastrointestinal ileus

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NSHP – Severe Clinical Signs by System

Neurologic

- Ataxia, tremors, seizures
- Tetany, flaccid paralysis

Musculoskeletal

- Fibrous osteodystrophy
- Pathologic + folding fractures, bowing of long bones
- Scoliosis, kyphosis, lordosis
- Translucent teeth, may fall out
- Chelonians –
  shell deformities, pliability, curving of the scutes, pyramiding

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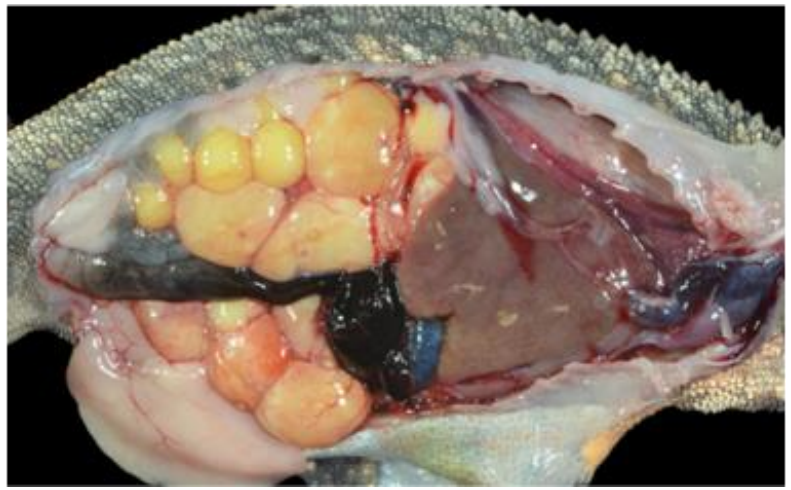
NSHP – Severe Clinical Signs by System (cont.)

Gastrointestinal

- Colonic +/- cloacal prolapse
- Bloating
- Intestinal impaction

Reproductive

- Oviductal prolapse
- Preovulatory (follicular) stasis
- Post-ovulatory stasis – dystocia, egg retention, poor egg quality



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NSHP – Diagnosis

- Anamnesis, physical examination
- Biochemistry panel – total Ca, P, Ca:P ratio
  - Ionized calcium
  - Bound calcium – chelonians
  - Plasma calcidiol – NOT calcitriol
- Radiographs
- Quantitative CT or dual-energy X-ray absorptiometry

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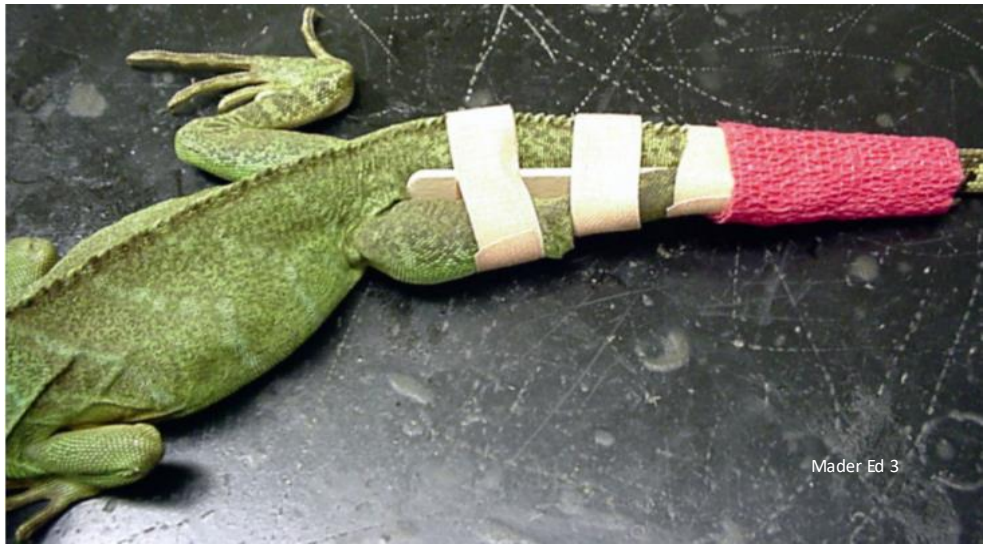
NSHP – Treatment

- Client education on husbandry
- Stabilize critical animals
  - Address seizures
- Calcium supplementation
  - Injectable
  - Oral
- Sunlight or UVB light
  - NO Vitamin D3 or P supplementation
- Strict cage rest
- Fracture coaptation – analgesia!



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NSHP – Prognosis

- Several prognostic indicators
- Multiple deficiencies
- Paralysis, urinary retention, obstipation
- Decreasing bone radiopacity
- Hypocalcemia
- Small chelonians with soft shells – anorexia at presentation

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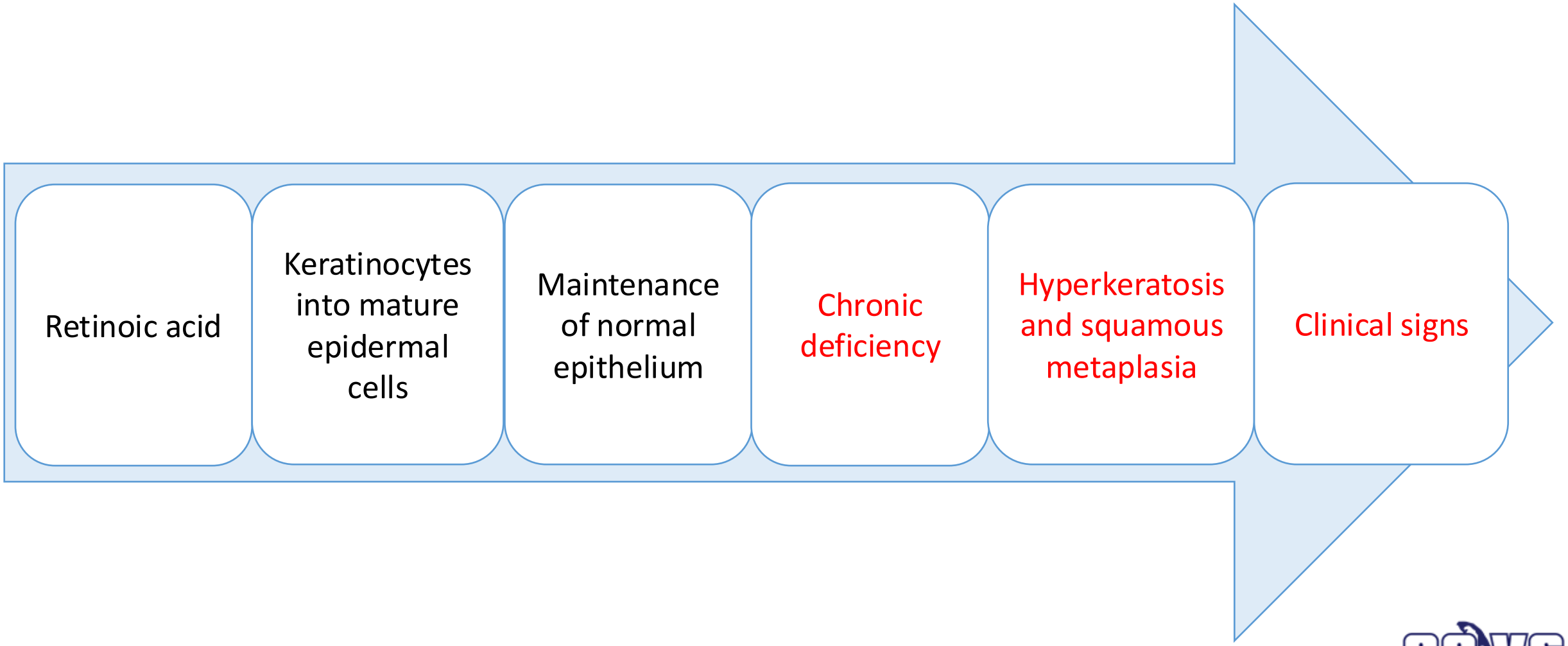
Hypovitaminosis A (HypovitA) – Pathophysiology



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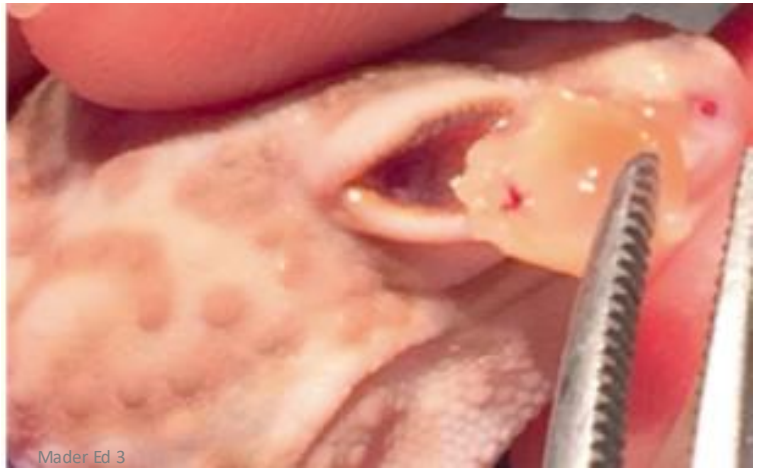
HypovitA – Clinical Signs by System

Nonspecific

- Weight loss
- Hyporexia, anorexia
- Lethargy



Ocular

- Obstructed or abscessed glands
  - Leopard geckos – periocular, on cranium
- Xerophthalmia
- Dysecdysis of spectacle
- Keratitis, keratomalacia
- Corneal ulceration, scarring
- Blindness

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HypovitA – Clinical Signs by System (cont.)

Oral

- Irregular thickening of lips and mouth
  - Especially oral commissures
- Lingual nodules

Integument

- Dysecdysis
- Dull coloration
- Discoloration

Reproductive

- Hemipenal plugs – impaction, infection

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HypovitA – Clinical Signs by System (cont.)

Respiratory

- Upper respiratory infections
- Pneumonia
- Especially in chameleons

Aural

- Tympanic or peri-aural abscessation
- Especially in chelonians, chameleons, leopard geckos

Renal

- Gout
- Insufficiency

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HypovitA – Diagnosis

- Anamnesis, physical examination
- Response to therapy
- Skin biopsy – squamous metaplasia
- Vitamin A values?
    - Post-mortem liver biopsy

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HypovitA – Treatment and Prognosis

- Client education on husbandry
- Response to treatment is SLOW
- Careful removal of cellular debris in eyes
- Most cases – oral supplementation
  - Human-grade vitamin A gel caps – 2000 IU/kg PO q7-14d x 2-4 treatments
- Severe cases – injectable vitamin A – beware of oversupplementation
- Recovery can take weeks
- Severe corneal ulcers and blindness
  - Especially for geckos

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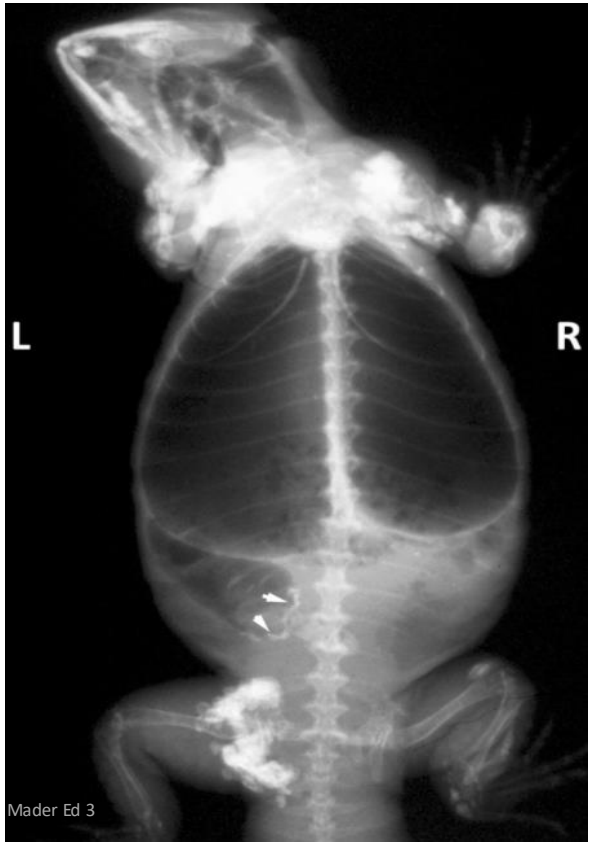
Toxicoses – Vitamins

- Vitamin A
  - Epidermal sloughing, bullae, blisters
  - Wound care, fluid support, analgesics
- Vitamin D
  - Hypercalcemia
  - Renal disease
  - Metastatic calcification



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Toxicoses – Firefly Ingestion

- *Photinus* sp. containing lucibufagin
- Cardiotoxic
- Focal facial seizures, head shaking
- Mouth gaping, lingual protrusion
- Nausea, vomiting
- Dyspnea, rapid death
- No known effective therapy

Obesity

- Common in captivity
- Overrepresentation – varanids, bearded dragons, red eared sliders, larger boids
- Etiology
- Decreases lifespan
- Increases risk for other diseases
- Treatment
  - Gradual weight loss
  - Caloric restriction
  - Exercise

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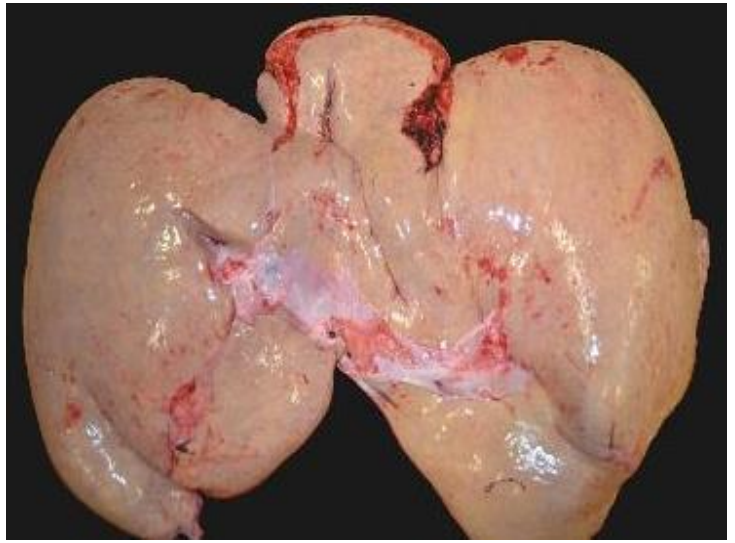
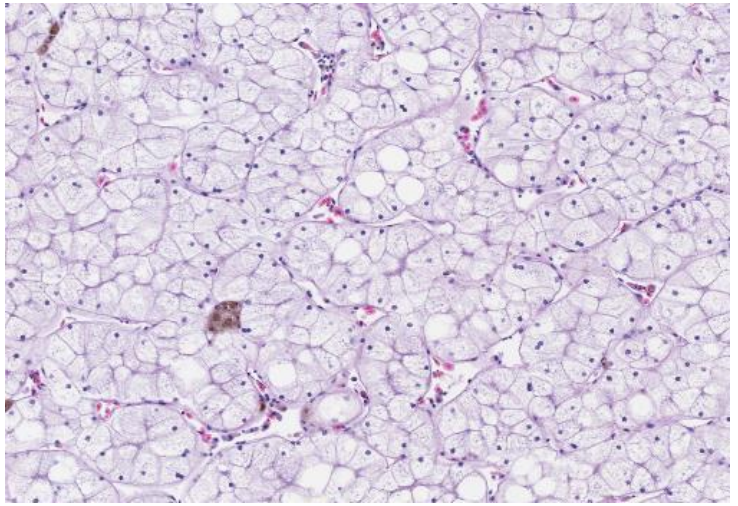
Hepatic Lipidosis

- Definition – pathologic accumulation of lipid within hepatocytes
- Etiology – obesity, chronic hyporexia
- Clinical signs – anorexia, lethargy, preovulatory stasis, altered mentation
- Diagnostics – anamnesis, biochemistry panel, imaging, liver biopsy
  - Beta-hydroxybutyrate in bearded dragons?
- Treatment – nutritional support, hepatoprotectants
- Prognosis – guarded





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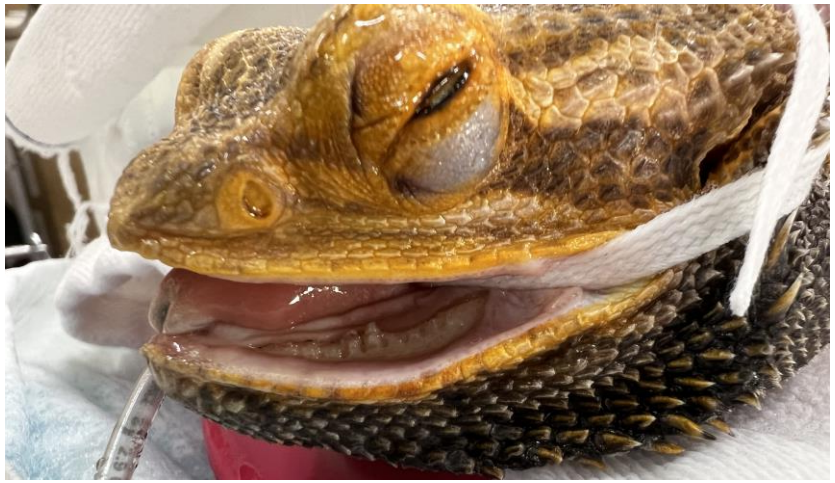
Periodontal Disease

- Lizards with acrodont dentition
  - Teeth are not shed or replaced
  - Agamidae, Chameleonidae
- Trauma, dessication of gingival tissue
- Periodontitis, stomatitis, osteomyelitis
- Cleaning under heavy sedation/anesthesia
- Cleaning at home, antibiotics as indicated



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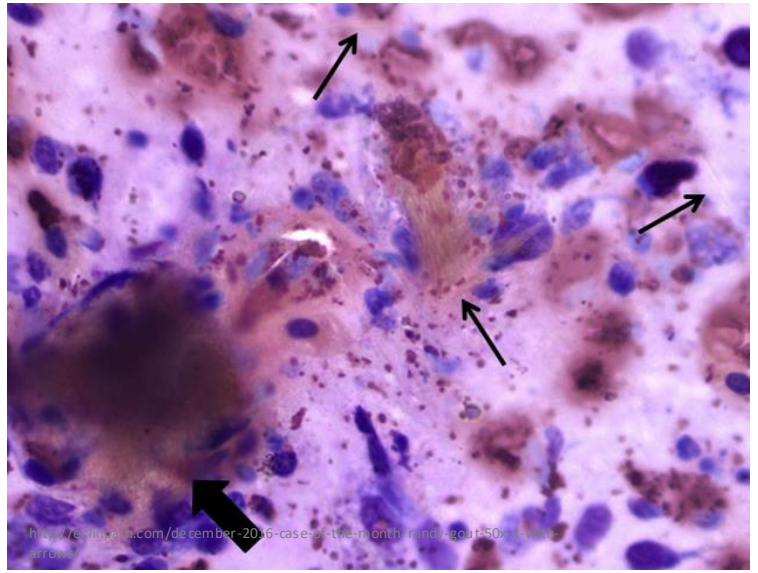
Gout and Hyperuricemia

- Definition – hyperuricemia ≠ gout
- Etiology – dehydration, nephropathies, high protein diets
- Clinical signs – dehydration, joint swelling if articular/peri-articular
- Diagnosis – radiographs, FNA is definitive
- Treatment – allopurinol, analgesics, hydration
- Prognosis – poor for advanced stages, visceral gout
- Prevention



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Nutritional Support for Sick Reptiles

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Prior to Feeding

- Appropriate temperature
- Correct dehydration
- Food is warmed (as indicated)

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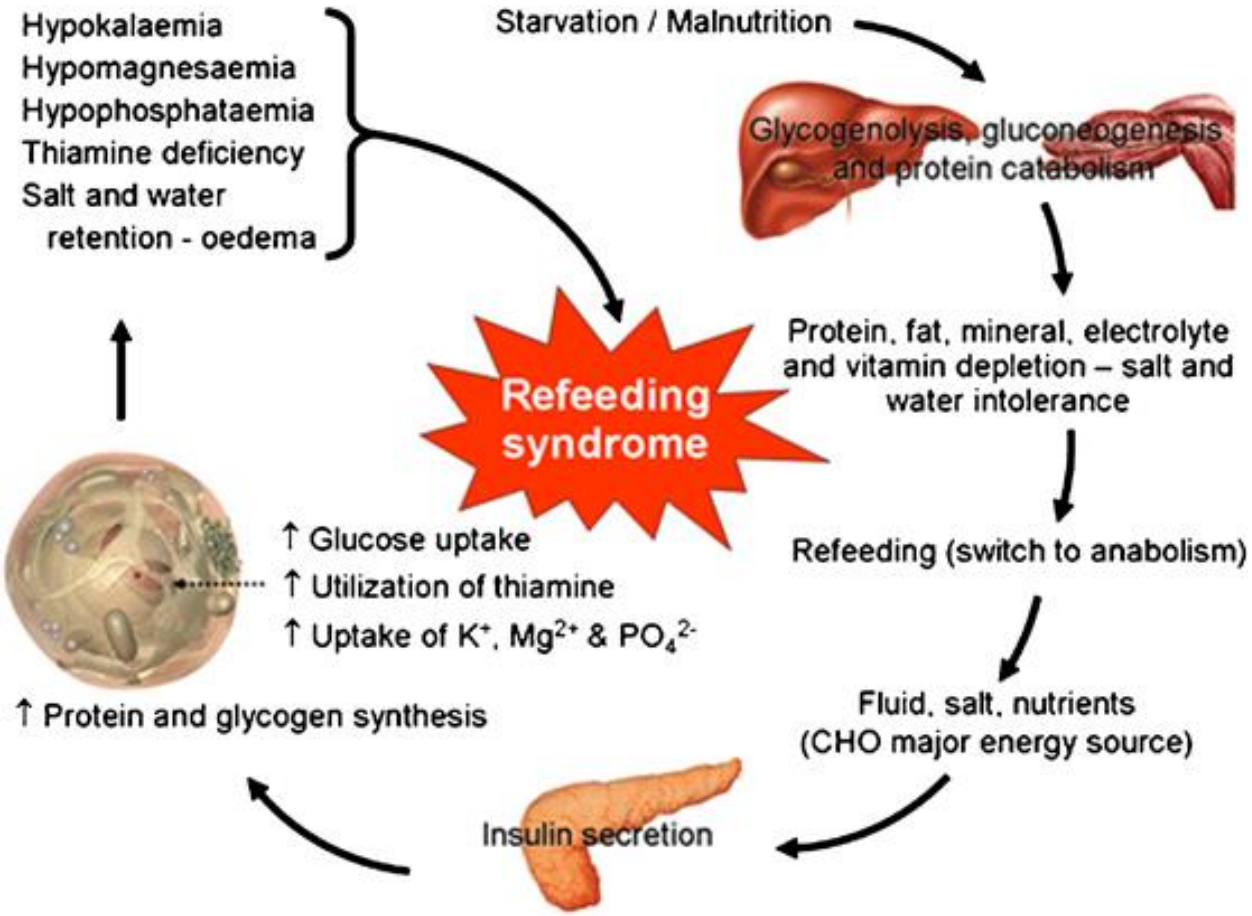
Refeeding Syndrome

- Physiologic anorexia ≠ refeeding syndrome
- Signalment – ill, starved, cachectic animal
- Prevention
  - Rehydration for 2-4 days
  - Limit to 10-25% of calculated requirements
  - Increase over days to weeks
- Monitor electrolytes if possible



https://www.researchgate.net/publication/6138422_Nutrition_in_clinical_practice_-_The_refeeding_syndrome_Illustrative_cases_and_guidelines_for_prevention_and_treatment/figures?lo=1

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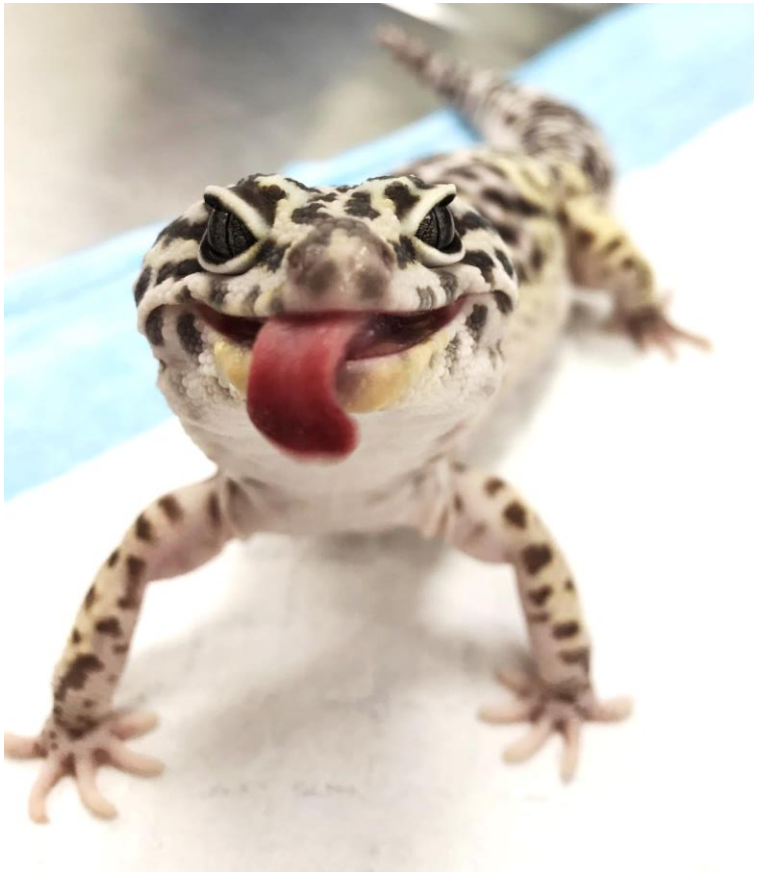
Fluid Administration

- Maintenance = 10-30 ml/kg/d
- Isotonic fluids most commonly administered
- Soaking, SQ, IV, IO
- Other routes
  - Intracoelomic
  - Oral fluids
  - Cloacal

Assist Feeding

- Hand/tease feeding
- Syringe feeding
- Regular diet
- Commercial diets



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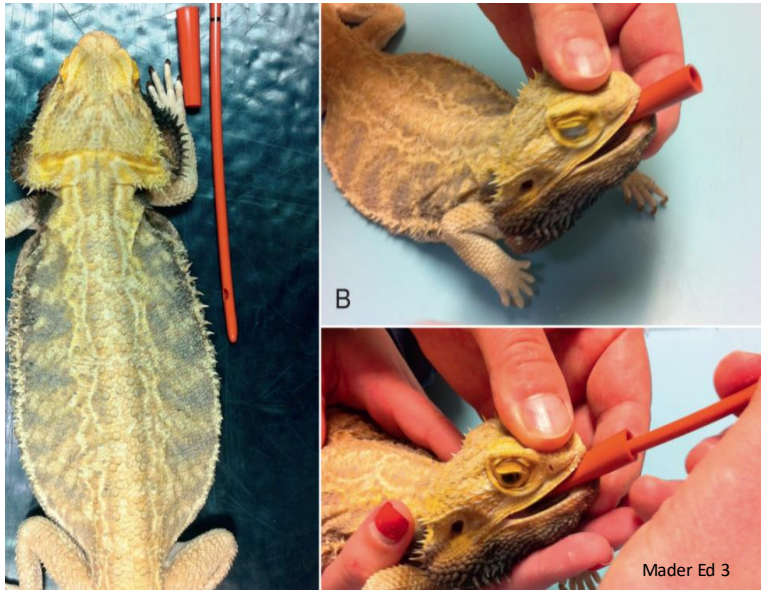
Gavage Feeding/Esophagostomy Tube

- Stomach tube
  - Red rubber catheter
  - Speculum
  - Lizards/snakes > chelonians
  - ~ 5-25 ml/kg
- Esophagostomy tube
  - Chelonians
  - Confirm placement with contrast radiography or CT



Increasing Owner Compliance

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Before the Appointment

- Online husbandry forms
  - Filled out ahead of time
- Pictures of enclosure, lighting, food, supplements
- Incentivization

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During the Appointment

- Compassion is key
- Budget time to review husbandry and nutrition
- Technician to do at end while clinician is writing discharges/prescriptions, etc
- Have client-friendly care sheets ready to go
  - ARAV has great care sheets

- Triage what is most important for client to modify first
- Highest priority – temperature, access to water, humidity, water quality, UVB
- Medium priority – nutrition, feeding location, substrate
- Lower priority – exercise vs cage rest, enrichment, cage size

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After the Appointment

- Follow up phone call or email
- Schedule recheck appointment
- Encourage and support client
    - Congratulate on the small wins

QUESTIONS?

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NOTICE

CE credit certificates & presentation slides will be emailed to you. If you do not receive an email with this information within a week, contact Nichole - *nicholemanfredi@capecodvetspecialists.com*

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