Reptile Nutrition 101: Veggies & Insectivores Delight

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Reptile Nutrition

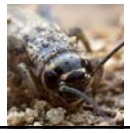
- 1: The Diet Types
- 2: Vegetarian Menu
- 3: Happy Meal Menu
- 4: Food Prep

Where do nutrition guidelines come from?

- National Research Council
  - Comprehensive research
  - Minimum nutrient guidelines for domestic animals
  - www.nap.edu for free online access
- What's the word on herptiles?
  - Extrapolated from other species
  - Minimums for rats most commonly used
  - Nutritional Advisory Group: http://nagonline.net/

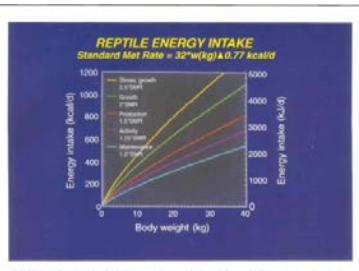
What are the diet groups for reptiles?

- Comparison to mammals
  - Carnivores
    - Examples: Monitor, tegus, chameleons, leopard geckos, ring neck snake
  - Omnivores
    - Examples: Bearded dragons, water dragons, box turtle, red eared sliders
  - Herbivores
    - Examples: Green iguana, tortoises, geckos



What Does a Reptile Need?

- Reptiles
  - Standard metabolic rates for daily energy needs at optimal temps: 32 BWkg $^{(0.75)}$



Mader 2006, Nutrition (S.Donoghue)

Energy

Diet breakdown: Chelonians

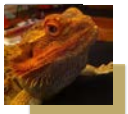
AQUATIC TURTLES
- Aquatic Veggies
- Feeder fish
- Pellets
- Insects

BOX TURTLES
- Weeds, Garden Veggies
- Slugs/earth worms
- Berries
- Flowers

TORTOISES
- 100% plants only
- Weeds, fibrous roots
- REMEMBER= adapted to live in the Desert

Diet breakdown: Lizards

HERBIVORES (Salad) & FLOWER EATERS
- Iguanas
- Uromasty x
- Chuckwallas



OMNIVORES: Bugs and Salad
- Bearded Dragons
- Anoles
- Blue Tongue Skink
- Veiled Chameleons
- Tegus

INSECTIVORES & CARNIVORES: Bugs and mammals
- Leopard Geckos
- Monitor Lizards
- Some Chameleons
- Frilled Dragons

SPECIALIZED HERPS
- Fruit /Nectar Feeders
- Crested Geckos
- Columbian Tegus

Snakes: Almost ALL CARNIVORES

Temperate
- Cornsnake
- Milk snakes
- Rat snakes
- Kingsnakes

Tropical
- Ball pythons
- Pythons & Boas
- Snakes from Central/South America

Specialized Diets
- Insects, amphibians, feeder fish
- Garter Snakes
- Rainbow Boas
- Ring-Neck Snakes
- Hog Nose
- Egg Eating Snake

Vegetable Dinner Wheel

Dandelion Greens

•Good calcium source (Ca:P is 1.3:0.4)
•Good source for Vitamin A: 2712 IU
•Good for Vitamin C: 20mg per cup
•86% water, 18% Protein, 11% fiber,5% fat , Carbs 61%

Romaine Lettuce

•Good calcium, Ca:P (1.1:0.4)
•Great source of Vitamin A 5837IU and Vitamin C 24mg
•Protein 36%, fiber 11%,
•94% water, 7% fat, Carbs 50%

Collard Greens

•Calcium (1.0: 0.1)
•Vit. A 2400IU
•Vit. C 12.7 mg
•Water 96%
•Protein 0.88g
•Fiber 1.3g
•Carbs 2.05g

Mustard Greens

•Good calcium, Ca:P is 1:0.3
•Great for Vitamin A 5880 IU
•Great for Vitamin C 39.2mg
•Water 93%, protein ,
• Fiber 1.8g, Carbs 2.74g
•Supplement with Lite table salt

Red Leaf Lettuce

Calcium 9mg
Vit. A 2098IU
Vit. C 1mg
Water 92%
Protein 0.37g
Fiber 0.3g
Carbs 0.63g

Vegetable Dinner Wheel

Escarole

Calcium (1: 0.9)
Vit A: Mod. source
Vit. C: Mod Source
Water 92%
Protein 1.7%
Fiber 4%

Endive

Good Calcium (1:0.6)
Vit. A 542 IU
Vit. C 1.6 mg
Water 92%
Protein 0.31g
Fiber 0.8g
Carbs 0.84g

Swiss Chard

Calcium to Phos 1:1
Vit. A 6116 U
Vit. C 30 mg
Water 93%
Protein 1.8g
Fiber 1.6g
Carbs 3.74g

Bok Choy

Calcium 74 mg
Vit. A 3128U
Vit. C 31.5mg
Water 95%
Protein 1.05g
Fiber 0.7g
Carbs 1.53g

Kale

Calcium to Phos 1.63
Vit. A 9990 U
Vit. C 120 mg
Water 84%
Protein 4.28g
Fiber 3.6g
Carbs 8.75g

Spinach

Calcium to Phos 2.02
Vit. A 9370 U
Vit. C 28 mg
Water 91%
Protein 2.86g
Fiber 2.2g
Carbs 3.61

Hay Science!

www.oxbowanimalhealth.com

The Insect Menu

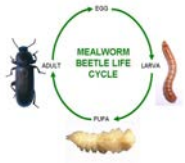
- What do we know about insect composition?
  - Formally studied for more than 50 years
- Why have we been studying it?
  - Culture food for insectivores in captivity
  - Mealworms first proposed as a staple diet option for new world primates

The Menu

Domestic cricket, *Acheta* *domesticus* (Barker 1998, Finke 2002, Finke 2005, Allen 1989, Anderson 1989)

The Menu

Mealworm, *Tenebrio molitor* (Barker 1998, Finke 2002, Fraenkel 1950, Jones 1972, Klasing 2000, Wallach 1972, Martin 1976, Hunt 2001, Zwart 1979, Oonincx 2012)



The Menu

Superworm, *Zophobas morio* (Barker 1998, Finke 2002, Oonincx 2012)

The Menu

Earthworm, *Lumbricus terrestris* (Barker 1998, Finke 2002)

The Menu

Silkworm, *Bombyx mori* (Finke 2002, Finke 2007)

The Menu

Phoenix worm larvae *Hermetia illucens* (Dierenfeld 2008, Finke 2012)

The Menu

Madagascar hissing cockroach, *Gromphadorhina portentosa* (Oonincx 2012)

The Menu

Turkistan or red rusty cockroach, *Blatta Lateralis* (Finke 2012, Oonincx 2012)

The Menu

Butterworm or tebo worm, *Chilecomadia moorei* (Finke 2012)

The Menu

Fruit fly, *Drosophilia melanogaster* (Barker 1998, Finke 2002, Finke 2012, Oonincx 2012)

Insect Menu

These species are on the market but are not as well-studied . . .

Dubia cockroach, *Blaptica dubia*

Insect Menu

These species are on the market but are not as well-studied . . .

Hornworm, *Manduca quinquemaculata*

Insect Menu

Not readily on market, but occasionally available . . .

False katydid
Microcentrum rhombifolium

Wood louse
Porcellio scaber

Basic Components of Nutrition

- Metabolizeable energy
- Fat
- Protein
- Vitamins
- Minerals

Metabolizeable Energy

- Definition
  - Net energy gained from food after digestion and absorption
- Measurement
  - kilocalories per kilogram (kcal/kg)
- Factors that impact ME
  - Species, age, activity, and environmental temperature
    - In reptiles, temp not maintained by ME
    - Require fewer calories than mammals

Metabolizeable Energy

- Reptiles
  - Standard metabolic rates for daily energy needs at optimal temps: $32\ BWkg^{(0.75)}$
  - 500g reptile needs 9.5- 57 kcal/day @ 86F
- What does inverts offer as calories?
  - 0.7 - 2.7 kcal ME/g

Metabolizeable Energy

Invert	ME kcal ME/g
Butterworms	**2.977**
Wax worms	**2.747**
Superworm larvae	**2.423**
Phoenix worms	1.994
Cricket	1.402
Mealworm larvae	1.378
House fly	0.918
Red Turkish roach	0.244
Earthworm	0.708

Oonincx 2012, Finke 2002, Finke 2012

Protein

- Definition
  - Amino acid composition and availability
- Measurement
  - g/kg or % DM
- Insect protein sources
  - Exoskeletons contain amino acids
  - Bioavailability may be limited
    - Dierenfeld 2008: Phoenix Worms

Protein

Invert	Crude Protein g/kg
Mealworm larvae	**237**
Cricket	**205**
Superworm larvae	197
House fly	197
Phoenixworms	175
Butterworms	155
Waxworm	141
Earthworm	105
Silkworms	93

Dierenfeld 2008, Finke 2002, Finke 2012

Lipid Content (Fat)

- Definition
  - Energy from essential fatty acids
  - Aids in fat soluble vitamin absorption
  - Increases palatability
- Measurement
  - % DM or g/kg

Lipid Content

- NRC min for rats
  - 5% or 50 g/kg of diet fed (growing)
  - Nec. for fat soluble vitamins
- Lipid content in feeder inverts
  - 3 – 6 x higher than rodent diets
- Is fat bad for herps?
  - Species dependent, strict insectivores rely on fat more than omnivorous
  - Activity

Invert	Crude Fat g/kg and (% Fat)
Waxworms	**249**
Superworm larvae	**177 (as high as 40.1%)**
Phoenix worms	140
Cricket	68 (as high as 22.8%)
Mealworm larvae	54 (as high as 31.1%)
Fruit Flies	19
Earthworms	16 (12.6%)
Tenebrio beetles	(17.7%)
Zoophobas beetles	(14.3%)

Lipid Content

Lipid Content

Invert	Crude Fat g/kg and % Fat
Butterworms	**294**
Hissing Cockroach	(20.3%)
Red Rusty Cockroach	(14.5%)
Wood Louse	(11.3%)
False katydids	(9%)
Silkworms	14

Baker 1998, Oonincz 2012, Finke 2002, Finke 2012

Vitamin A

- Definition
  - Retinol, β carotene, retinyl esters
  - Fat soluble, light sensitive (supplements)
- Measurement
  - IU/kg
- Clinical Relevance
  - Poor levels in most insects
  - Hypovitaminosis A is a significant and common clinical problem in herptiles
  - Supplementation with beta carotene isn't as effective, must use retinol or retinyl esters

Hypovitaminosis A
Squamous metaplasia

- Palpebral edema
- Aural abscess
- Respiratory epithelium compromise
- Lingual squamous metaplasia
  - "Short Tongue syndrome" in amphibians
- Ulcerative chelitis
- Vision loss
- Growth deficits
- Gastrointestinal bloat
- Dermal ulcerations
- Acute death
- Septicemia

Vitamin A

- NRC min retinol for rats
  - 2,300 IU/kg
- Do we know min requirements for herptiles? (Donoghue 2006-Mader)
  - Box Turtles: 3 - 6 IU/g diet DM
  - Aquatic Turtles: 2 - 8 IU/g diet DM
  - Chameleons: 5 - 9 IU/g cricket DM
  - Foam nesting frogs: 230,000 IU vitamin A/kg of supplement (Fleming 2008)

Vitamin A

Invert	IU/kg
Cricket	<1000
Mealworm larvae	<1000
Superworm Larvae	<1000
Waxworm	<1000
Earthworm	<1000
Butterworms	< 300 ug retinol/kg
Phoenix worms	< 300 ug retinol/kg
House Fly	< 300 ug retinol/kg
Red Turkish Roach	120

Vitamin A

Invert	IU/kg
Silkworms	**1580**
-- Tenebrio beetles	12
-- Zoophobas beetles	41
Hissing Cockroach	182
Wood Louse	170
False katydids	**2953**

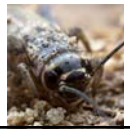
Oonincz 2012, Finke 2002, Finke 2012

Vitamin E

- Definition
  - Antioxidant vitamins
  - a-tocopherol
- Measurement
  - mg/kg and account the fat % in diet
- Clinical Relevancy
  - Inverts have adequate levels
  - Steatitis in deficient patients
- NRC rat min 18 mg/kg
- Insect range 5 – 166 mg/kg

Vitamin D3

- Definition
  - 25-hydroxycholecalciferol or calcidiol
  - Activated by photosynthetic mechanisms (UVB driven) in diurnals & crepuscular herps
  - Absorbed via intestine
  - Ca absorption and homeostasis
  - Serum levels are dependant on MS, renal, integument and GI health
- Measurement
  - ug/kg or IU/kg



Vitamin D3

- Clinical relevance
  - Calcium deficiencies across many orders of herptiles species
  - Very well studied in diurnal herbivores
- Insectivore supplementation?
  - Diurnal or crepuscular
    - House Gecko (Carmen 2000)
    - Jamaican Anole (Ferguson 2005)
  - Nocturnal
    - Leopard Geckos (Mitchell, ARAV 2013)

Vitamin D3

- Homemade vs. oral supplements
  - UVB first
    - Level comparable to natural history
    - Even nocturnal species can use UVB
  - Supplementation
    - Be careful
    - Inadvertent toxicity can occur
    - Insects "groom" powders off exoskeleton
    - If utilize, do so 1/week or less

Calcium & Phosphorus

- NRC min for calcium in rats
  - 3.5 - 5 g/kg
- NRC min for phosphorous in rats
  - 3 g/kg
- Insects
  - Ca: 0.089 – 9.3 g/kg
  - Phos: 1.5 - 3.7 g/kg

Showing Potential?

- NRC rat min calcium
  - 3 - 5 g/kg
- Phoenix worms
  - 9.3 g/kg
- Wood louse
  - 14% calcium DM
  - 11.79 Ca:P ratio
- Digestibility?

Phoenix worm larvae *Hermetia illucens* (Diererfeld 2008, Finke 2012)

Feeding Reptiles

- Commercial diets
  - Canned/dried prey items
  - Pellets
  - Powder/gel food
  - Vitamin/mineral supplements

Feeding Reptiles

Advantages	Shelf life of products Don't have to handle/care for live prey Consistent nutrition profile?
Challenges	Acceptance by reptiles Variable quality/nutrition content?

Care and Feeding of Prey

- General concepts
- Augmenting nutrition profile (vitamin/mineral)
- Housing examples
  - Cricket
  - Beetle larvae
  - Roaches
  - Moth and fly larvae

General Concepts Care and Feeding of Prey

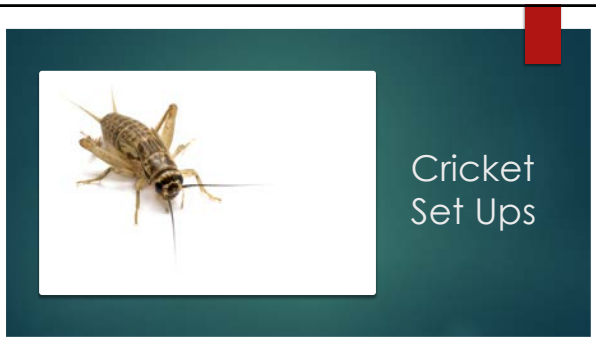
- Prey health important for insectivore health
  - Well hydrated
  - Well nourished, high quality diets
  - Infectious disease
- General
  - Don't feed directly from pet store or post-shipment
  - Need appropriate planning

Augmenting Nutrition

- Dusting
  - Shake invert in small particle dust prior to feeding
  - Imprecise way to guarantee supplementation
    - Insects can groom off dust or dust falls off
- Gut-loading
  - Short term feeding nutrient dense diet to prey
  - Many studies prove this method works for Ca
- Do both!

Care of Prey

- Housing
  - Containers and containment
  - Stocking density/surface area
  - Substrate/hides
- Temperature, humidity
- Nutrition
  - Water
  - Food


Cricket
Set Ups

The Development and Evaluation of a Gut-Loading Diet for Feeder Crickets Formulated to Provide a Balanced Nutrient Source for Insectivorous Amphibians and Reptiles

Lydia Attard , March, 2013

- Soybean Flour
- Sweet Potato Flour
- Red Lentil Flour
- Spirulina
- Crushed Rabbit Alfalfa Pellets

24 hour Gut-Load

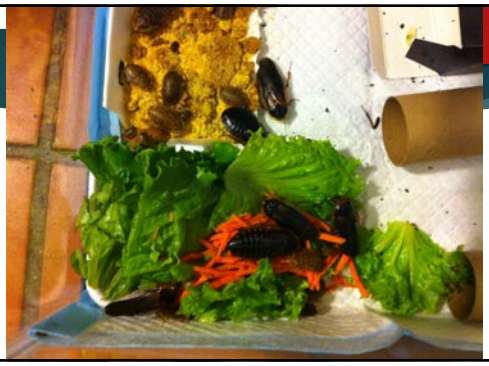
Fly Set Ups

- *Drosophilia melanogaster*

c

Roach Set Ups

- Popular:
  - Death Head, Lobster, Dubias, Turkish, Hissing
- Dubia Blaptica:
  - Cannot climb glass
  - Adults live 1-2 yrs
  - Breed constantly
  - Quiet & No Odor



Madagascar Hissing Roaches

- Gromphadorhina portentosa
- Large, easy to care for
- Tropical
- Can Climb glass
- Adults: 2-3 yrs
- Babies take 3 months to mature

Courtesy of Yang Li (Ph/MD Penn med student)

ButtersWorms

- Buttersworms or Trevoworms (*Chilecomadia moorei*)
- Irradiated prior to import in the US to prevent molting.
- Store in fridge for weeks.
- Gut-Load 24 hrs prior?

Reptiworms,Calciworms and Phoenix Worms

- Phoenix worms are the larvae of the Black Soldier Fly (*Hermetia illucens*)
  - Well studied, used in aquaculture
  - Stored in cups at room temp

http://www.ie.unc.edu/for_students/courses/capstone/13/bsfl_how-to_guide.pdf

Horn & Silk

- Hornworms (Manduca quinquemaculata) usually come in a cup with feed
- They grow fast and eat non-stop
- Feed to insectivores within 7-10 days depending on desired size
- Large specimens
- May need cuticle
- laceration

Horns & Silk

- Silkworms (*Bombyx mori*) are picky eaters!
- Diet: mulberry leaves . . Hence the vitamin A
- Most vendors sell them with a food substrate.
- Store are room temp and feed them out within 7-10 days
- Moisture of feed can promote fungal growth

Earthworms

- *Lumbricus terrestris*
- Substrate
  - Dirt
- Food:
  - Composting scraps
  - Can gut load 24 hrs prior

Confused yet?

Nutrient Content - Happy Meal Version

	Insect is known For	Human Food Comparison	Staple or Treat?
Domestic Cricket	Low protein, high fat (22.8%)	French Fries	Staple if gut loaded, otherwise a treat
Roaches	Lean protein with variable fat (14 - 50%)	Hamburger to Steaks	Staple
Silkworms	Some vitamin A, lean protein source	Turkey	Staple
Earthworms	Protein, good micronutrient content	Big Mac® + multi-vitamin	Staple
Phoenix Worms	Calcium content high	Tums® tablet	Staple, macerate prior to feeding
Butterworms	High ME and fat content (29% DM)	2 Hotcakes with sausage (25%)	Treat, recovery diet
Mealworm larvae	Fat (31%)	2 McDouble Hamburgers ®	Treats
Superworm Larvae	Fat (40.8%)	Two Sausage Egg & Cheese Biscuits (46%)	Treats
Waxworm larvae	More fat (51.4%)	Butter (53% fat)	Treat
Freeze-Dried or Canned	Variable moisture and high in fat	Doritos® Slim Jim®	Treat, use sparingly

Take Home Points

- Larval insects
  - High in fat
  - Poor in vitamins and minerals
  - Variable protein bioavailability
- Adult beetles, earthworms, and roaches
  - Lower fat
  - Good protein levels (esp. earthworms)

Nourish Your Prey

- Most insects have poor calcium levels
  - Increase with supplements
  - Phoenix worms have high Ca content
  - Macerate to increase bioavailability
- Insect care
  - Well-hydrated
  - Well nourished
  - Feed calcium rich diet at least 24 hrs prior (not more than 9% total calcium)
  - Can be kept at home/bred at home

Bon Appetit!

- http://www.insectsarefood.com/recipes.html

Thank you