



Turtle Anatomy, Husbandry, and Triage

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Turtles are Turtley Amazing!

- There are ~357 recognized species of turtles worldwide (IUCN)
 - Approximately 50% of these are globally threatened which makes rehabilitation especially important!
 - Turtles are over 200 million years old
- Here in North Carolina: **16 species** of non-marine turtles and **5 species** of sea turtles (21 total)
 - 14 freshwater semi-aquatic
 - 1 brackish water semi-aquatic (DBT)
 - 1 terrestrial (EBT)
 - 5 marine turtles (loggerhead, green, hawksbill, Kemp's ridley, and leatherback)
- To learn more about our native species of turtles visit the herpsofnc.org
 - [https://herpsofnc.org/turtles/#:~:text=Turtles%20are%20found%20throughout%20North,Box%20Turtle\)%20is%20primarily%20terrestrial](https://herpsofnc.org/turtles/#:~:text=Turtles%20are%20found%20throughout%20North,Box%20Turtle)%20is%20primarily%20terrestrial)



Turtle Trivia!

- What is the state reptile of North Carolina?

North Carolina State Endangered Species Act US FWS Federal Endangered Species Act (FE, FT)

- **Endangered species:**

- Atlantic hawksbill sea turtle (*Eretmochelys imbricata imbricata*) FE
- Kemp's ridley sea turtle (*Lepidochelys kempii*) FE
- Leatherback sea turtle (*Dermochelys coriacea*) FE

- **Threatened species:**

- Bog turtle (*Glyptemys muhlenbergii*) FT
- Green sea turtle (*Chelonia mydas*) FT
- Loggerhead sea turtle (*Caretta caretta*) FT

- **Species of special concern:**

- Cumberland slider (*Trachemys scripta troostii*)
- Diamondback terrapin (*Malaclemys terrapin*)
- Eastern chicken turtle (*Deirochelys reticularia reticularia*)
- Eastern spiny softshell (*Apalone spinifera spinifera*)
- Northern map turtle (*Graptemys geographica*)
- Stripeneck musk turtle (*Sternotherus minor peltifer*)

**That's 57% (12/21) of our total NC turtle species
[Non-marine 44% (7/16)]
...that we know of!**

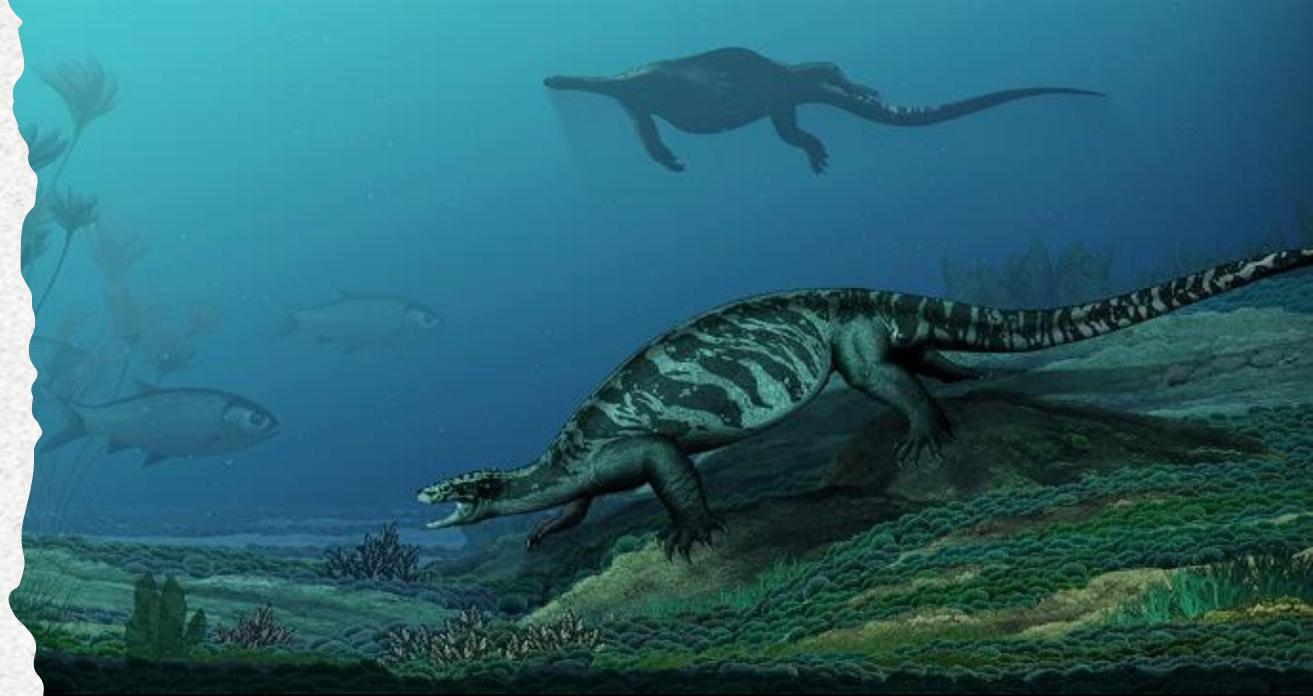
PROTECTED WILDLIFE SPECIES OF NORTH CAROLINA



North Carolina Wildlife Resources Commission
ncwildlife.org
October 1, 2021

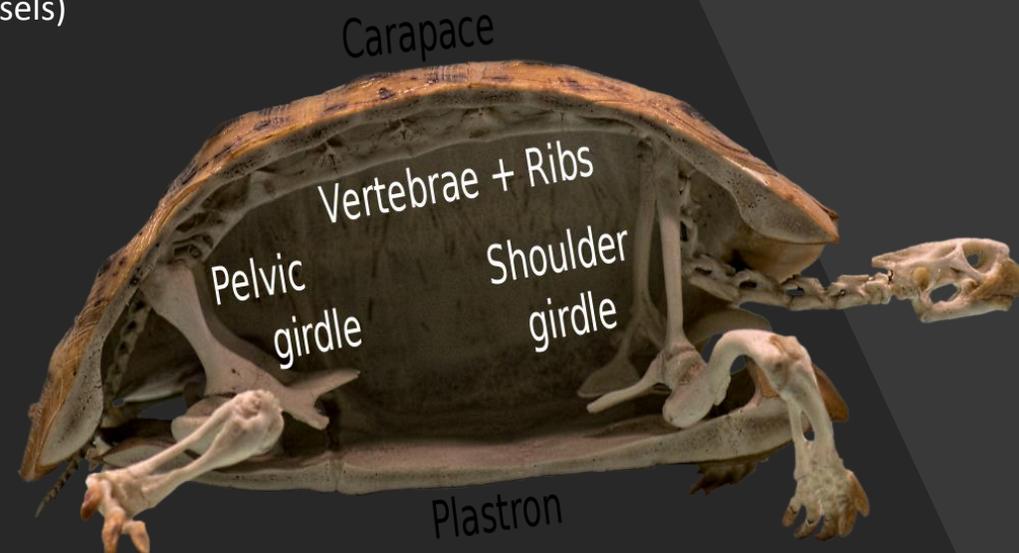
A 220-million-year-old turtle!

- *Eorhynchochelys sinensis*
- Discovered in southwestern China on August 22nd, 2018
- Adds another piece to the shell puzzle!



Turtle Anatomy

- The shell!
- Breathing
 - Lack a diaphragm
 - Movement of the pelvic and pectoral muscles act as a mammalian diaphragm to change intrapulmonary pressures
- Circulation
 - 3-chambered heart (2 atria and 1 ventricle with an incomplete IV septum, 2 aortic arches)
 - For more about comparative anatomy visit: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5424407/>
 - Hepatic first-pass effect for medications administered in the caudal half of the body
 - Lower bioavailability, lower [plasma], and reduced or no efficacy
 - Renal portal system: In turtles this system receives veins from the carapace and muscles posterior to the kidneys.
 - This is why injections are often given in the cranial half!
- No lymph nodes (complex network of perivascular lymph channels around major vessels)
 - This is why many venipuncture locations can have lymphatic contamination
- Thymus is maintained into maturity
- The vent/cloaca – three chambers (like in the bird)
 - Anterior chamber (coprodeum) – feces
 - Middle chamber (urodeum) – urogenital duct
 - Posterior chamber (proctodeum) – general area for digestive/excretory waste



Reptiles are ECTOTHERMS

Preferred Optimal Temperature Zone (POTZ)

This means they directly depend on environmental heat sources to regulate their body temperature

Always ensure your reptile is in POTZ prior to feeding/medicating!

A gradient allows the reptile to CHOOSE different thermal areas

Temperature gradients are species-specific

Species	POTZ (day)	POTZ (night)
EBT	78-89F	70-75F
Freshwater	80-84F	65-70F

In general, most diurnal reptiles require a range of 80-90F with a basking area of 85-95F

Heat sources for terrestrial turtles may include various lamps, heating pads (UTH), heat tapes, radiant heat

Aquatic turtles may require a submersible water heater

Reptiles maintained for prolonged periods at 60-70F appears to be too cold for normal digestion and immune response and too warm for brumation.

UVB: Most species benefit from natural sunlight and outdoor enclosures or sunning time when climates are appropriate.

Humidity: Terrestrial species have different humidity requirements too!

Turtle Trivia!

What turtle is considered endothermic and is able to generate/control body temperature from within?



- Hospital environment: thermal gradient, clean/dry enclosure, newspaper substrate, water source, hiding place
 - Once turtle is stable providing a more suitable enclosure during rehabilitation that closely mimics their natural environment is important for overall turtle health and welfare.
- Natural light is one of the best resources for captive reptiles (appetite stimulant, other)
- UVB light is recommended for most reptiles to create vitamin D3
 - Necessary for absorption of Ca from GI
 - Deficiency may result in nutritional secondary hyperparathyroidism (NSHP)
- Ambient light and photoperiods are important for health and reproduction
- Temperature range is important for immune function and digestion
- Immune responses appear to be lower in winter months (more susceptible to infections)
 - One of the most dangerous times for captive reptiles is at the end of hibernation (early spring)
 - Sudden death is common secondary to a “post hibernation immunity gap”
- Privacy hides and humid hides (ecdysis, egg laying, hydration)
- Stress can be caused by inappropriate temperatures, lighting, humidity, hiding places, photoperiods which predisposes them to a weakened immune response
- Water changes!
 - To help freshwater reptiles avoid skin lesions salt may be added to the water
 - 1 cup (~300g) of sea salt to 20gal (80L) of water provides brackish water concentrate that reduces risk of infection without increasing risk of dehydration.
- Disinfection and spot cleaning!



Enclosure Size?

- Enclosure size for turtle and tortoises is often recommended related to their body lengths.
 - The bigger, the better!
 - ~ 3x carapace length (or ~5x body length in the case of snappers and other turtles with elongated appendicular skeletons)
 - ~40% of the cage should be open floor space to move and feed.
- For more details on enclosure size recommendations visit:
<https://www.anapsid.org/enclsize.html>

Aquatic And Semi-Aquatic Turtles

Dimension	Carapace Length
Minimum length (side to side):	4-5 x
Minimum depth (front to back):	2-3 x
Minimum height:	1.5-2 x total length plus 8-12" to prevent escapes

Terrestrial (Box) Turtles And Tortoises

Dimension	Carapace Length
Minimum length (side to side):	5 x
Minimum depth (front to back):	3 x
Minimum height:	1.5-2 x to prevent escapes

Diet

- Stomach volume of most chelonians is estimated to be **~2% (20ml/kg) of body weight**
 - Maximum gastric volume for many reptiles is not known
 - Stomach volume is reduced with anorexia
 - Start with 5ml/kg/feeding slowly increase volume over several days to weeks
 - **Too large volume or too rapid administration risks regurgitation → aspiration pneumonia → death**
 - Multiple small feedings >> one large feeding
- Anorexic – consider referral for esophagostomy tube placement and intensive nutritional management
- Refeeding syndrome – too much nutrition too quickly to a debilitated animal leading to metabolic derangements
 - First and always, rehydrate!
 - Then, start with 10-20% of the calculated caloric requirements and increase over the first 3 weeks.





How much does my patient need to eat?

- Daily maintenance energy/calorie requirement (MER) can be estimated: $32 (BW^{0.75})$
 - BW is in kilograms
 - Units: kcal/day
 - Based on temperature $\sim 86^{\circ}\text{F}$ (30°C) (Donaghue 2006)
 - Caloric needs increase with shell trauma (Donaghue 2006)
 - Bone makes up 15-30% of body weight and requires energy for repair!

There isn't a "one size fits all" formula and certainly more research is needed as we have $\sim 12,000$ species of known reptiles which are all unique!

There are other formulas and factors out there based on species, life stages, patient requirements, environmental factors so consulting with your veterinarian or referral of critical cases is often recommended.

Gavage or E-tube Feeding Example

Your patient is a 500g EBT

- Remember to **convert your grams into kilograms** (500g = 0.5kg)
 - If you are uncomfortable with conversions use Google converter to double check!
- Calculate **MER: 32 (BW^{0.75})** → $0.5\text{kg} \wedge 0.75 = 0.594 \rightarrow 32 \times 0.594 = \sim 19 \text{ kcal/day MER}$
- Calculate your patient's stomach volume** (~2% which would be $500\text{g} \times 0.02 = 10\text{mL}$)
 - Species stomach volume varies. Also, remember if your patient hasn't eaten, it's stomach volume will shrink!
- Select your diet** → each diet will have different concentrations/mixing instructions
 - Oxbow Critical Care Omnivore is **~30kcal/tablespoon**
 - So, 19 divided by 30 means that this turtle would require ~0.6 tablespoons (or **~2 teaspoons**) of dry product daily to meet MER
 - Package directions have a general recommendation of **1 Tbsp (~8grams) of dry product per kg of body weight** daily
 - This calculation matches *closely* with our MER calculation (it won't always match based on your patient's needs) = **~1.5 teaspoons.**
 - Mixing direction **1 part powder to 1 part water**
 - This may be too thick for the tube diameter or too rich for your patient to start on right away
- General conversion: 1 tablespoon (3 teaspoons) ~ 15mL
 - So, for our patient to get 2 teaspoons that would be ~10mL which is the estimated stomach volume!**

Rule of thumb: Nutrition is complicated and is often tailored to the individual's needs

- Other factors include body condition, metabolic state, reproductive status, trauma status, etc.
- Feedings may need to start small or more dilute
- Feedings often need to be broken down into smaller feedings; several smaller feedings will be better than one large feeding

Risks:

- Aspiration → pneumonia → death!**
- Always check the food temperature prior to administering to prevent secondary burns
- Always check your patient's temperature prior to feeding to ensure POTZ for appropriate digestion



Table 1. Recommended diet for the adult, omnivorous semi-aquatic turtle

Category	% of adult diet	Examples
Plant material	≥ 50%	<ul style="list-style-type: none"> Dark, leafy greens like kale, romaine, Swiss chard, watercress, endive, bok choy, escarole, spinach, duckweed, collard greens, mustard greens, dandelion greens, beet greens Mix greens with coarsely chopped yellow or dark orange vegetables (e.g. shredded carrots, squash), green beans, or broccoli of appropriate size. Fruit, like apples, melons, grapes, oranges, bananas, and berries, can also be offered occasionally.
Commercial diet	≤ 25%	<ul style="list-style-type: none"> Aquatic Turtle Formula, Fluker Farms Freshwater Turtle Diet, Mazuri Reptimin Sticks, Tetra Reptile Sticks, Wardley
Animal protein	≤ 25%	<ul style="list-style-type: none"> Whole small fish (goldfish, guppies, bait minnows, smelt) Snails in the shell Small frogs Insects (mealworms, waxworms, earthworms, bee moth larvae) as an occasional treat Chopped mice or whole pinky mice as an occasional treat



Freshwater Semi-Aquatic Turtle Diet

<https://lafeber.com/vet/wp-content/uploads/Aquatic-turtle-handout-color-copy.pdf>

Turtle Trivia!

- What is the oldest living turtle on record (Guinness World Records)?



Turtle Trivia!

What is the smallest species of turtle in North America?



What is the smallest species of turtle in the world?



Triage of Shell Trauma

- Approximate the age of the injury
 - Fresh (< 6 hours)
 - Contaminated (6-24hr)
 - Contaminated/infected (>24hr)
- Excellent Prognosis:
 - Fresh shell injuries that is not infected (< 6 hours)
 - Single nondisplaced fracture without spinal involvement
 - Minor excoriations
 - May require simple supportive care and topical medications
 - Time in care: few days to weeks of supportive care

Triage of Shell Trauma (continued)

- Good Prognosis:
 - Multiple, unstable and/or open fractures
 - Malunion will have bone exposed or missing pieces of the bony carapace/plastron
 - *if large pieces are missing or coelomic membrane is breached then prognosis changes
 - Dog/animal bites with shallow shell puncture(s)
 - If these injuries are fresh they have a good prognosis
 - If these injuries >24 hours old they are contaminated and prognosis decreases to fair to guarded depending on degree of contamination/infection
 - Often require more supportive care, surgical stabilization, +/- antibiotics
 - Time in care: several months

Triage of Shell Trauma (continued)

- Fair Prognosis
 - Multiple fractures involving the pectoral or pelvic girdles
 - Penetrating punctures of the coelom
 - If these injuries are >24hr prognosis becomes worse
 - Fractures of the caudal shell narrowing the pelvic canal can lead to dystocia in females; must consider spay, captive animal, or euthanasia
- Guarded Prognosis:
 - Open fractures
 - Punctures to viscera (i.e. plastron fracture with liver damage)
 - Internal organs extruded from fractures or have large amounts of debris and maggots are difficult to treat successfully due to organ damage and infection

Triage of Shell Trauma (continued)

- Grave Prognosis – Humane Euthanasia considered
 - Multiple fractures, internal injuries, head and spinal injuries
 - Reproductively active females with depressed fractures resulting in yolk coelomitis
- Spinal walking – can mask spinal injuries!
 - Reflexive action, not a conscious movement
 - This is how reptiles may walk around a severed spine
 - Other issues also arise with spinal injuries such as denervation of the bladder and lower GI
- Bone healing in turtles may take 1-6 + months
 - Simple closed fractures may have appropriate stabilization in 4-8 weeks ; more severe 12+ weeks
 - Primarily base fixator removal on the stability of the fracture
 - When in doubt, leave it on longer!
- General principle is to fix fractures with an open system (don't seal up a contaminated wound)

Initial Management – Shell Injury

- Clean and remove debris
 - Dilution is the solution to the pollution!
 - Warm sterile saline or LRS and dilute betadine 0.1-1%
 - Low to moderate pressure
 - To create the recommended ~8psi use a 1L fluid bag with a cuff pressurized to 300mmHg and an 18g needle
- Topicals
 - SSD: good for most shell/skin wounds
 - Honey: variety of wounds; honeycomb is great for packing into wounds and can be impregnated with honey
 - Medihoney (medical grade leptospermum honey): expensive, but can be used for open coelomic cavity wounds and deep shell fractures. Comes in several forms.
 - Wound Gels: Help maintain a moist and antiseptic environment
 - Epoxy cement: cover screws/wires. Waterproof. Can add further stability.

Releasable or not?

Before release of any reptile, many factors must be considered, and compliance reviewed with national, state, and local laws.

- Humane Euthanasia Considerations:
 - Crushing skull injury
 - Severe shell crush with open celomic cavity and organ damage
 - Bilateral non-treatable eye damage (i.e. bilateral proptosis)
- Shell repairs: Can be released as long as the repair is inconspicuous to predators
- EBT/Aquatic turtles may be releasable with limb amputation(s)
- Considerations for remaining in captivity / deeming non-releasable
 - Non-visual
 - Multiple amputations which affect ambulation
 - Severe pelvic / neurological injuries (females)
- Soft release (acclimated) vs. hard release (no acclimation)
 - Release as close to the original location as possible for best chance of reacclimating and to prevent disease spread

Isolation

- Turtles with upper respiratory signs should be isolated and treated last/separately from other turtles with appropriate biosecurity
- Examples may include:
 - Oral plaques
 - Conjunctivitis/palpebral swelling
 - Ocular and/or nasal discharge
 - Infectious shell lesions – newly described keratinophylic turtle shell fungus
 - Unknown pathobiology/transmission – be cautious to be safe
- Biosecurity protocols:
 - Wearing/changing gloves between patients
 - Washing hands between patients
 - Keeping isolated/quarantined turtles in a separate room or dividing the area with a shower curtain to provide a mini-isolation set up to reduce respiratory transmission
 - Treating isolation turtles last and use separate materials specific to isolation (bandaging supplies, eye drops, etc.)
- If a turtle has a severe signs these may require additional diagnostics (i.e. radiographs, CT scan) and medications (systemic antibiotics, nebulization, other)

Turtle Trivia!

For male EBT, how can we estimate anemia without a blood sample?



Venipuncture

- Locations:
 - Jugular – this is my favorite site to reduce risk of lymphatic contamination. Limitations may include holder experience and head trauma.
 - Dorsal coccygeal vein
 - Appendicular: brachial and femoral veins
 - Subcarapacial sinus
 - Occipital sinus
- Technique:
 - Calculate 1% BW for small patients.
 - To err on the side of caution I calculate 0.5% or the minimum needed for diagnostics (whichever is the smallest volume) depending on the patient's trauma/status.
 - Remember serial samples add up in our tiny patients
 - If it's a male EBT; look at the iris color!
 - Always clean the site prior to sampling (alcohol or alcohol / betadine)
 - Heparinize your syringe as turtle blood flow can be slow (clot)
 - Be sure to flush the syringe with heparin and expel extra heparin!
 - Needle/syringe will depend on the size of the patient
 - Most common: 25g needle on a 1cc or 3cc syringe
- Diagnostics: Even a small amount of blood can give you a lot of insight!
 - < 1 drop of blood for a blood smear, lactate, glucose
 - ~0.15mL for an iSTAT and PCV/TS
 - I use my microhematocrit tubes to take the last blood from the hub so no sample is lost

Fluids and hydration status

- It is difficult to detect early dehydration grossly in our turtle patients
 - ~10% Dehydrated if the eyes are sunken into the skull
 - Interpret with caution; if turtle is emaciated there may be concurrent atrophy of the orbital fat pad which can be perceived as extreme dehydration.
 - For turtle SC fluids I typically will calculate ~2% body weight and administer fluids into the inguinal, axial, or pectoral region
 - Caution with administration of SC fluids in the region of the shoulder as the lungs are right here!
- Dry docked water turtles will have a degree of dehydration and fluids should be supplemented
 - Monitor weight and clinical status
 - In these patients I also like to provide eye lubrication and misting
 - Soaking (inclines, shallow, other), nutritional “soup”
 - PO fluids
 - SC fluids
 - *Water turtles will not eat out of water*
 - Aquatic turtles absorb water when eating, when they are out of water they stop eating and dehydrate
 - *Water turtle pressure sores*
- You can fluid overload your turtle patient!

Medications/Therapies

*There are many medications available, these are some of the most utilized in turtles in TRT

- Antibiotics:

- Oxytetracycline
 - DILUTE ALWAYS – TISSUE NECROSIS
- Ceftazidime

- NSAID:

- Ketoprofen
- Ketorolac

- Eyes:

- Diclofenac O/S
- NeoPolyBAC (*NO steroid) O/O
- Ciprofloxacin O/S
- Blink or OptixCare lubricant gel

*steroids can be used; check for corneal compromise first!

- Systemic Analgesia

- Opioids

- Topicals

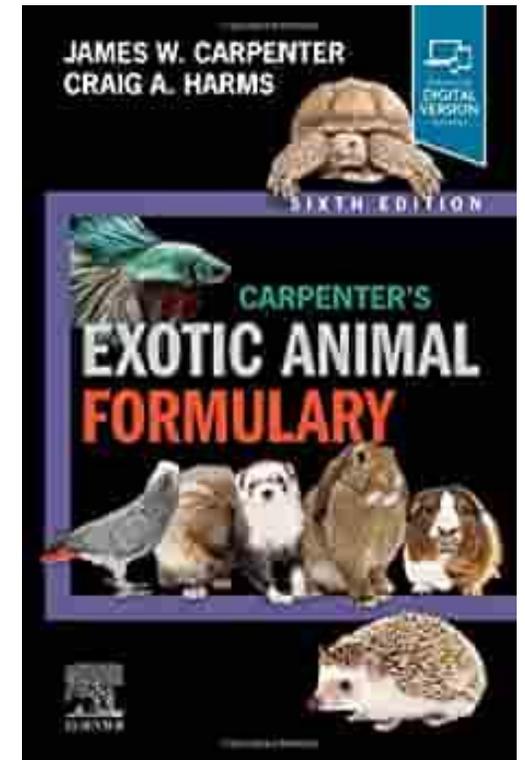
- TAO
- SSD
- Honey

- Local analgesia

- Lidocaine

- Nebulization

- LASER, acupuncture therapy, PT



For dosing, please consult a veterinarian, research/literature, formularies (Carpenter's)



REQUEST EXTRA-LABEL ADVICE

Food Animal Residue Avoidance Databank

ELDU AND WITHDRAWAL TIME | en Español

Whenever a drug is used in animals, there is a potential for drug residue in edible tissues and other foods consumed by humans. Edible tissues and food products include muscle, liver, kidney, fat, skin, milk, eggs, and honey.



Ivermectin Toxicosis in Chelonians

World Small Animal Veterinary Association Congress Proceedings, 2018

Y. Dewi

PET CARE, Practicing Veterinarian, Jakarta Selatan, Indonesia

INTRODUCTION

Ivermectin has been known to cause serious toxicosis in chelonians. Although the use of this drug is strictly contraindicated, there is always risk of accidental administration.

Medication Tips!

Anyone using drugs in a patient should consider these important factors

General rule for location: give **IM/SC medications in the cranial half of the body** and avoid the caudal half due to hepatic first pass effect and the renal portal system!

ALWAYS!

- Label your syringes or give immediately to avoid mixing medications/patients
- Check your patient's weight
 - Is that weight a month old? Has it lost/gained weight? Adjust your dose!
- Recheck your doses!
 - Does it require dilution due to drug causing tissue necrosis?
 - Does it require dilution to achieve a measurable dose for a small patient
- Check recent literature/formularies or with a veterinarian for dosing available
- Know the route you are administering and document location
- Reassess your patient daily
 - Does it still require pain control, how long has it been on antibiotics, is it responding clinically?
 - Monitoring bloodwork (i.e. known nephrotoxic, hepatotoxic drugs, etc.)
 - Monitoring through imaging
- Withdraw times? Is this a potential food species? Check with FARAD!
- Drug degradation? Does it require refrigeration, freezing, light protection, disposal after X days of opening?

If you don't know, ask!

Remember, no medication is given without risk

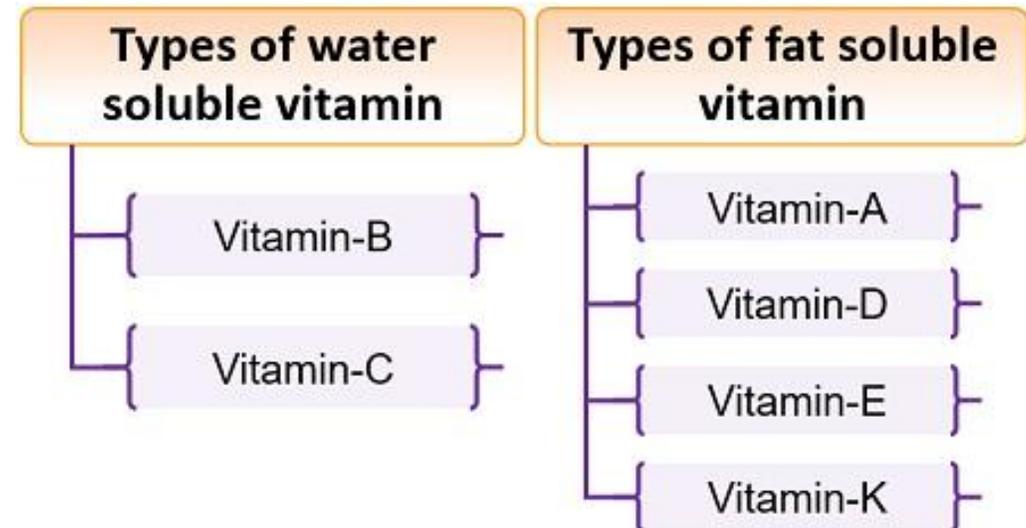
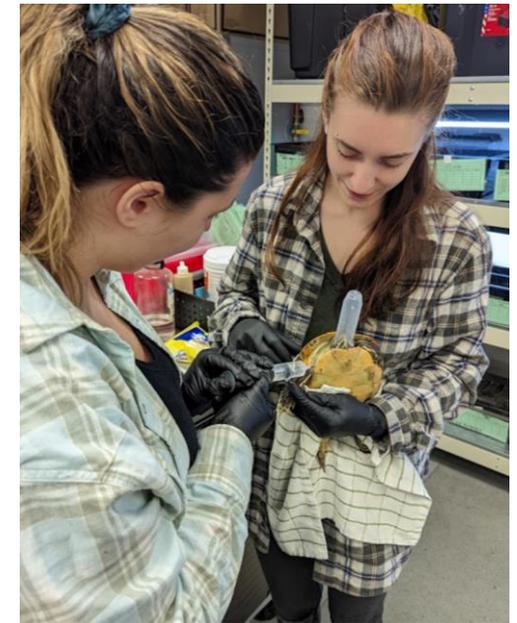
- Supplements
 - Oral/nutritional: Calcium, SeaTabs, other
 - Vitamins (injectable/oral)
- Fluids → LRS most commonly used for SC fluid administration
- Fluids, minerals, and fat soluble vitamins can be overdosed!!!

TABLE 132.3. Common Supplements, Doses, and Possible Side Effects

Supplement	Daily Dose	Possible Adverse Effects
B-complex: B ₁ , B ₂ , B ₆	5–40 mg	Nontoxic
Folic acid, B ₁₂	5–100 mg	Nontoxic
Vitamin C ^a	50–1000 mg	Considered nontoxic
Vitamin E	10–100 IU	Anorexia, increased clotting time
Vitamin A	500–5000 IU	Anorexia, weight loss
Selenium	5–50 µg	Anorexia, ataxia, weakness
Zinc	5–20 mg	Causes calcium/copper deficiency
Omega-3 fatty	25–250 mg	Dyspepsia, diarrhea ^b

^a Should have mixed bioflavonoids in C:bioflavonoid of 1:1 to 1:2.

^b Omega-3 fatty acids should be mostly from fish for carnivore supplementation; alpha-lanoline acid from seeds is converted more efficiently to helpful prostaglandins and leukotrienes or eicosanoids in herbivores.





TURTLE RESCUE TEAM

TURTLE RESCUE TEAM

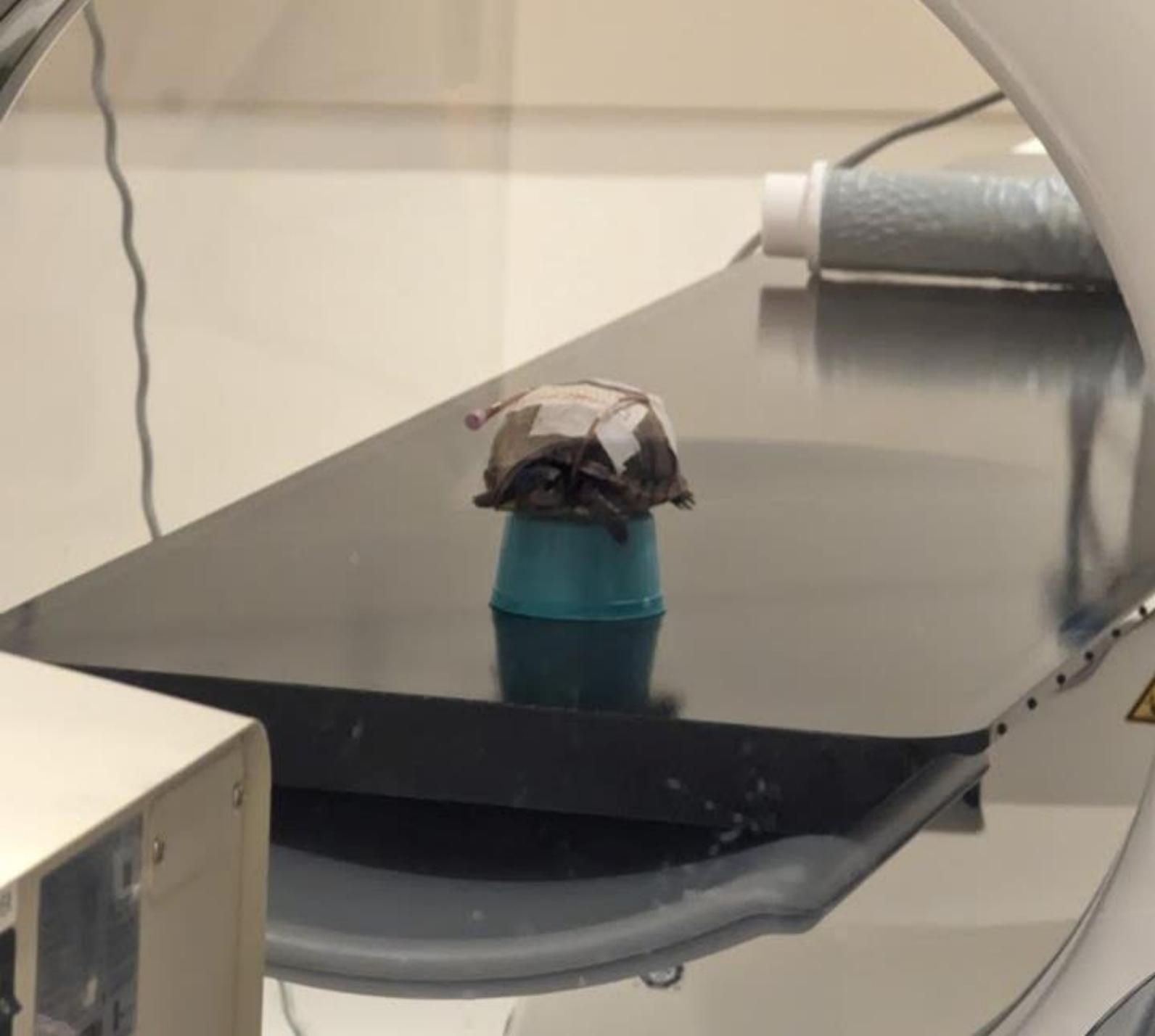
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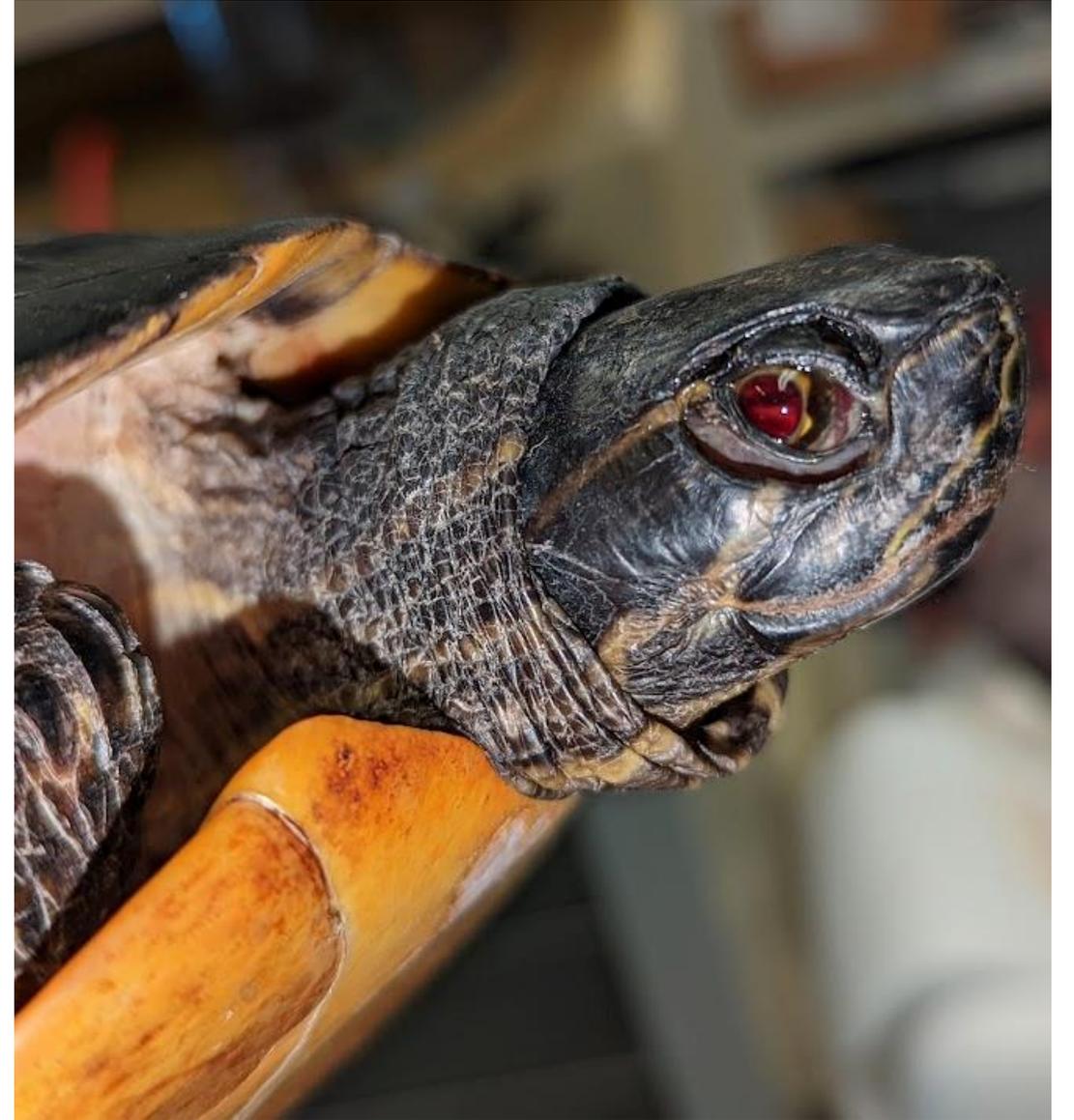
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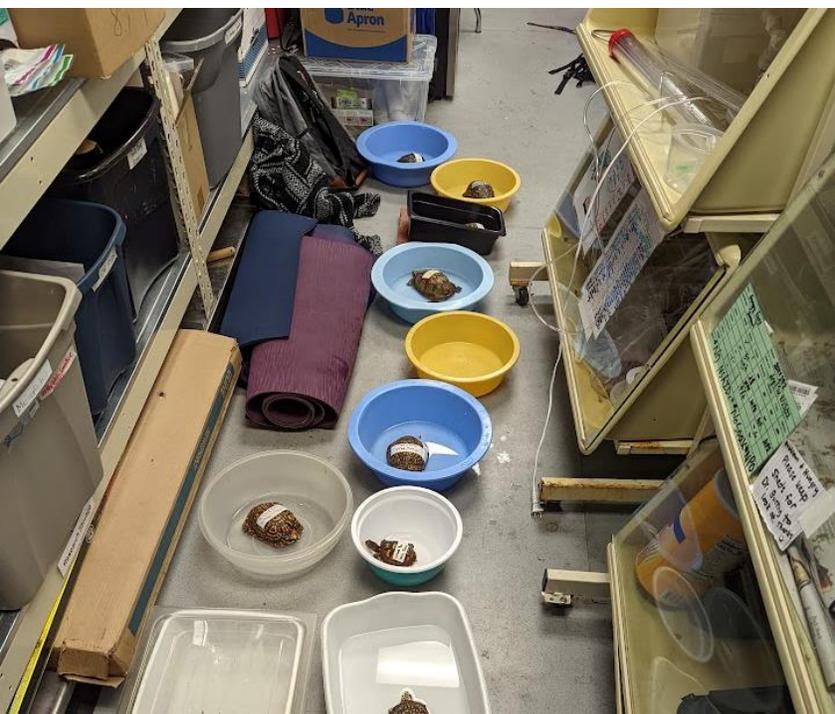
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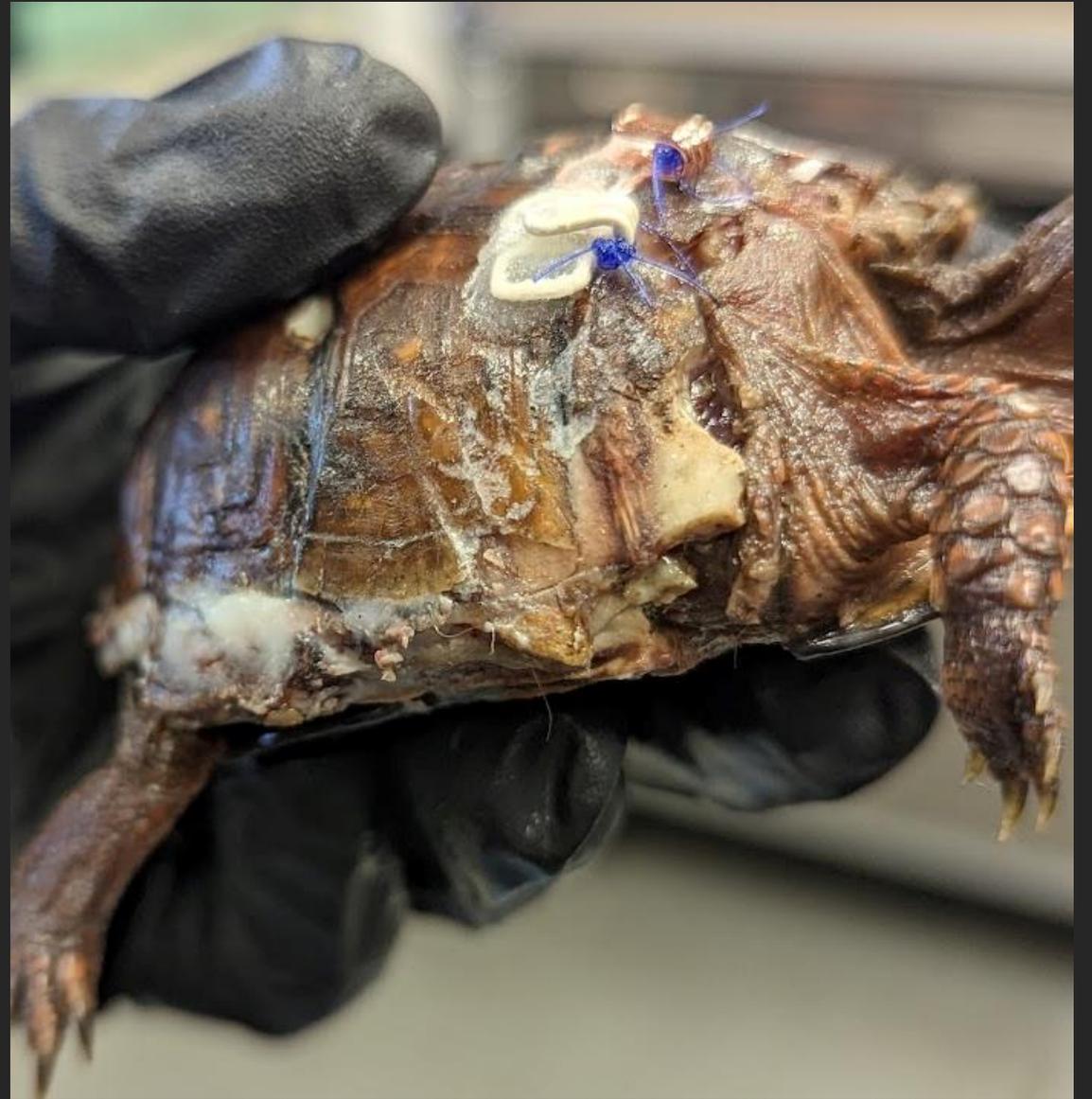








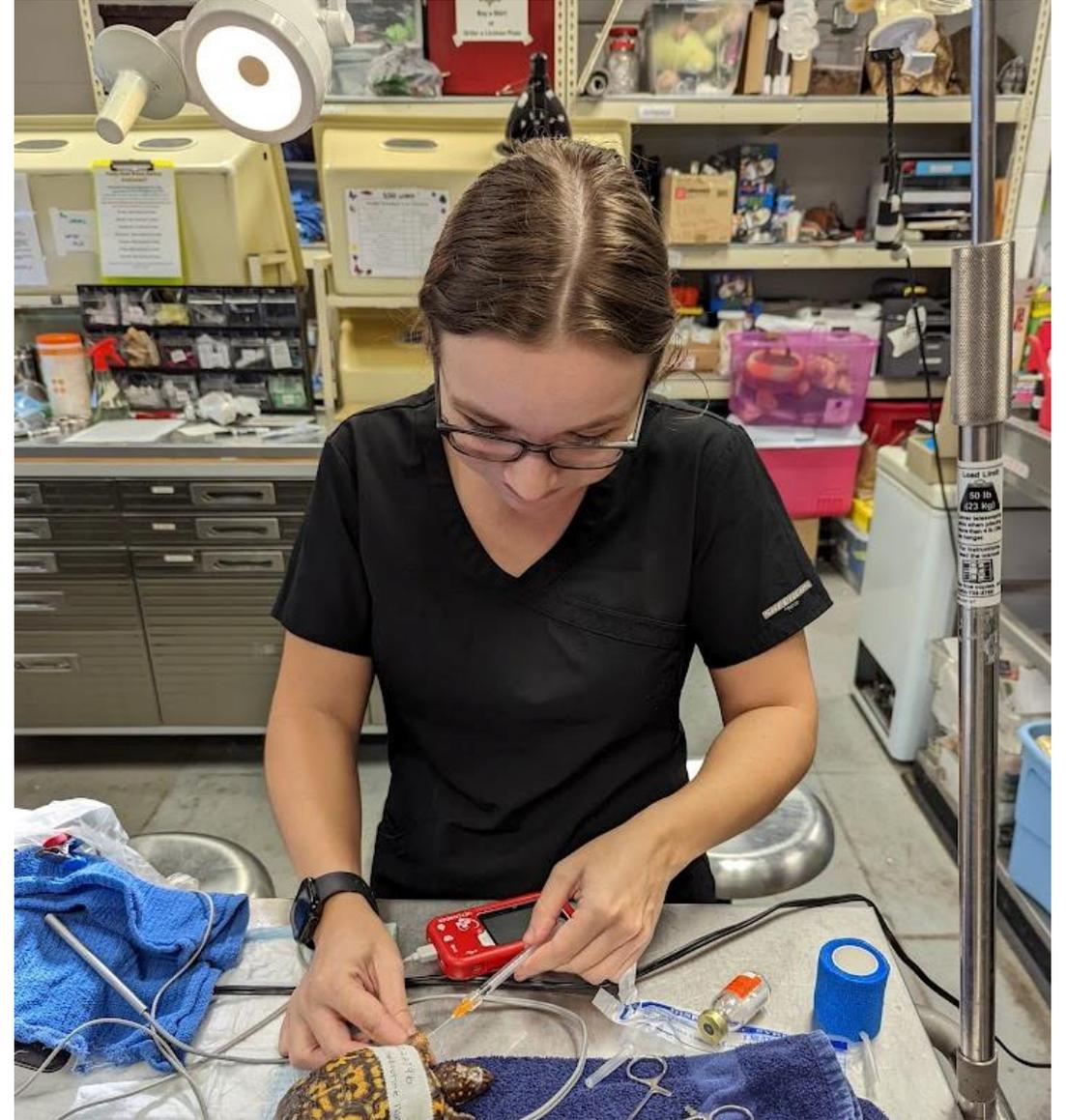






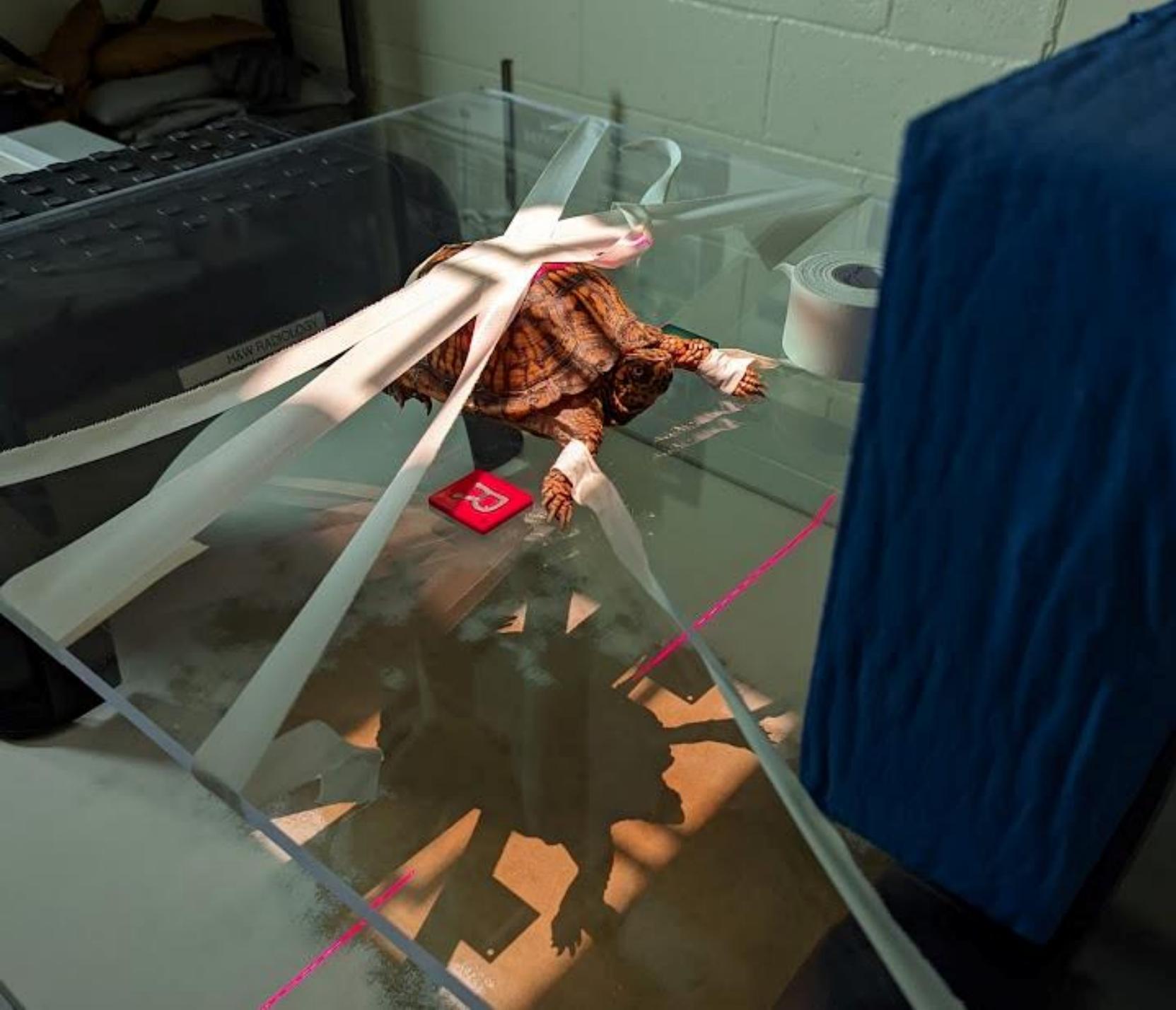












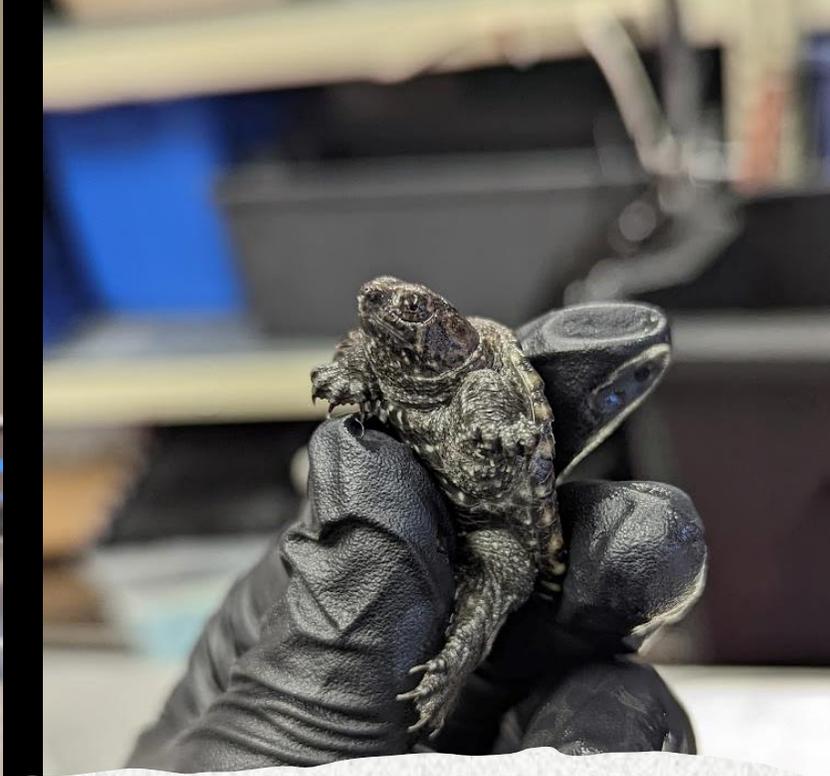


Resources

- Mader's Textbook
- Lafeber (<https://lafeber.com/vet/>)
- Oxbow
- EmerAid
- Carpenter's Exotic Animal Formulary
- North Carolina Wildlife Recourses Commission: www.ncwildlife.org
- NCWRC Protected Wildlife Species of North Carolina
 - <https://www.ncwildlife.org/Portals/0/Conserving/documents/Protected-Wildlife-Species-of-NC.pdf>

The screenshot shows the LafeberVet website interface. At the top, there is a navigation bar with links for 'HOME', 'REGISTER', 'LOGIN', and 'ENGLISH'. Below this is the LafeberVet logo and a search bar. The main content area is titled 'Basic Information Sheet: Box Turtle'. It features a large photograph of a box turtle in a natural setting. To the right of the photo is a 'Table of Contents' with links to various sections: Natural History, Taxonomy, Size, Diet, Husbandry, Lifespan, Anatomy/physiology, Husbandry, Venipuncture, Preventive medicine, Important medical conditions, and References. Below the photo, there is a section for 'Natural history' and a 'Taxonomy' section. The 'Natural history' section states that box turtles are indigenous to North America and spend much of their time in woodland and grassy habitats. The 'Taxonomy' section lists the class as Reptilia, order Chelonia/Testudines, and family Emydidae.

The cover of the 'Protected Wildlife Species of North Carolina' document features a collage of six images: a red-shouldered hawk perched on a branch, a hand holding a small dark animal, a brown snake, a black bat, a black bear, and a green frog. The title 'PROTECTED WILDLIFE SPECIES OF NORTH CAROLINA' is prominently displayed at the top. At the bottom, the North Carolina Wildlife Resources Commission logo is shown, along with the text 'North Carolina Wildlife Resources Commission', 'ncwildlife.org', and 'October 1, 2021'.



Thank you!

TRT:

Call 919-397-9675

E-mail turtle-rescue-team@ncsu.edu

Directions 1060 William Moore Dr, Raleigh, NC 27607

Mud or Musk?

Musk (*Sternotherus*)

- 1 plastron hinge
- Smaller plastron with more soft tissue/leg exposure
 - Think “snapping turtle” plastron
- More Aquatic
- Release a smelly musk which gives them the nickname “**stinkpot**”

Mud (*Kinosternon*)

- 2 plastron hinges
- Larger plastron than musk
- More time on land and shallow water
- Can live in fresh or brackish water!

