

Ill-effects of Confiscation Events in Box Turtles (*Terrapene* sp.) and Possible Solutions to Combat Disease Events

Wildlife Epidemiology Lab and Brookfield Zoo

MW Turtle Workshop
February 2024



Outline

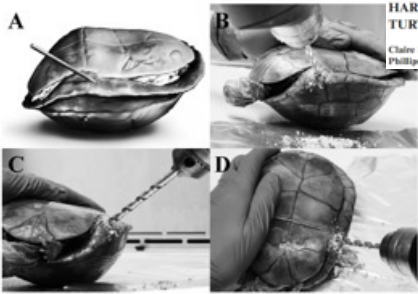
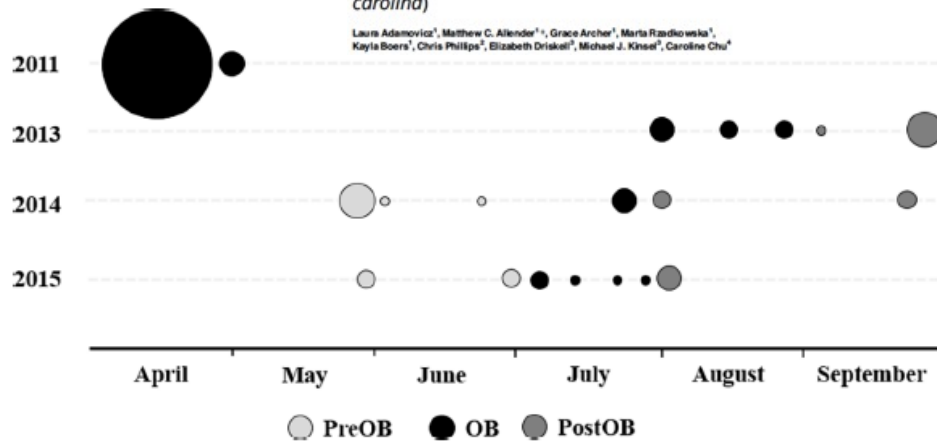


- Health of Box Turtles and Pathogens on the landscape
- Confiscation Events
- Future Directions and Conservation Outcomes

North American Box Turtles

Investigation of multiple mortality events in eastern box turtles (*Terrapene carolina carolina*)

Laura Adamovicz¹, Matthew C. Allender^{1*}, Grace Archer¹, Marta Rzedkowska¹, Kayla Boers¹, Chris Phillips², Elizabeth Driskell¹, Michael J. Kinzel³, Caroline Chu⁴



DETECTION OF RANAVIRUS USING BONE MARROW HARVESTED FROM MORTALITY EVENTS IN EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*)

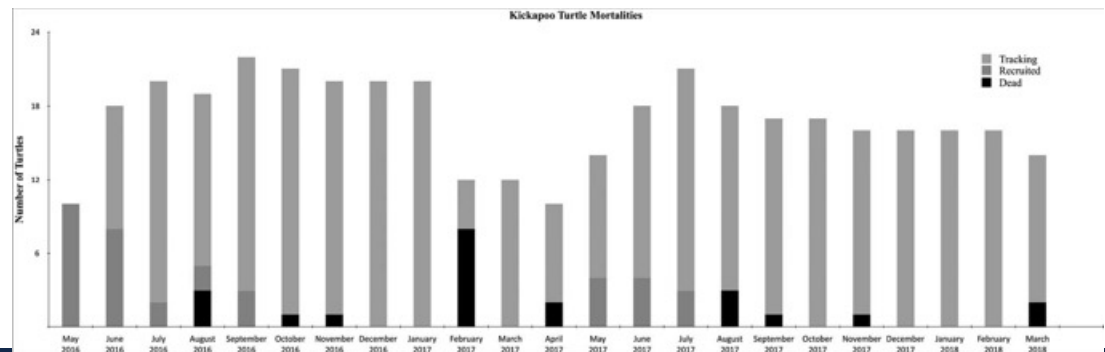
Claire E. Burkus, D.V.M., Matthew C. Allender, D.V.M., Ph.D., Dipl. A.C.Z.M., Christopher A. Phillips, Ph.D., and Laura A. Adamovicz, D.V.M.

Cause of Death	N
Unusual freezing event	7
Multisystemic infection	2
Reproductive stasis	2
Coelomitis	2
Ulcerative dermatitis	1
Meningoencephalitis	1



MORTALITY INVESTIGATION OF MONITORED EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) IN CENTRAL ILLINOIS, USA, FROM 2016–18

Jeremy M. Rayl,^{1,5} Laura Adamovicz,¹ Adam W. Stern,² Miranda D. Vieson,³ Christopher A. Phillips,⁴ Marta Kelly,¹ Michelle Beermann,¹ and Matthew C. Allender¹



North American Box Turtles

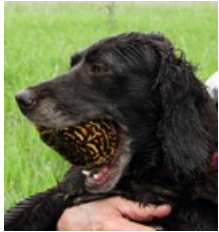


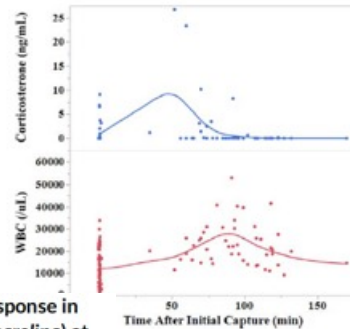
TABLE 4. Pathogen surveillance results of Eastern Box Turtle (*Terrapene carolina carolina*) and canine search dogs in Illinois in 2015.

Pathogen	Positive turtles	Negative turtles	Positive dogs	Negative dogs
Ranavirus (FV3)	0	109	0	109
<i>Terrapene herpesvirus 1</i>	8	101	0	109
Box turtle adenovirus	16	93	0	109
<i>Mycoplasma</i> sp.	21	88	0	109

Capture Effort, Rate, Demographics, and Potential for Disease Transmission in Wild Eastern Box Turtles (*Terrapene carolina carolina*) Captured through Canine Directed Searches

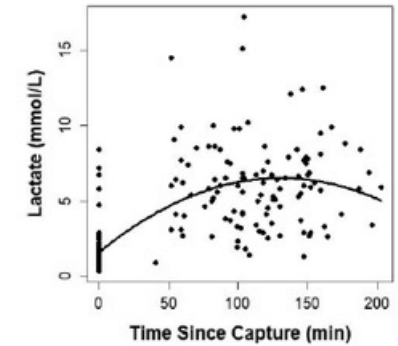
Assessment of hematologic and corticosterone response in free-living eastern box turtles (*Terrapene carolina carolina*) at capture and after handling

Kayla L. Boers¹ | Matthew C. Allender¹ | Lauren J. Novak¹ | Jamie Palmer² |
 Laura Adamovicz¹ | Sharon L. Deem²



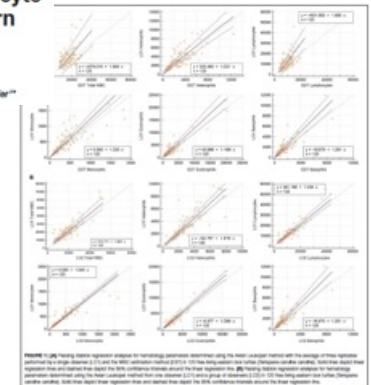
BLOOD LACTATE CONCENTRATIONS IN EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) FOLLOWING CAPTURE BY A CANINE SEARCH TEAM

Katy Klein, BS, Laura Adamovicz, DVM, PhD, Christopher A. Phillips, PhD, and Matthew C. Allender, DVM, MS, PhD, DACZM

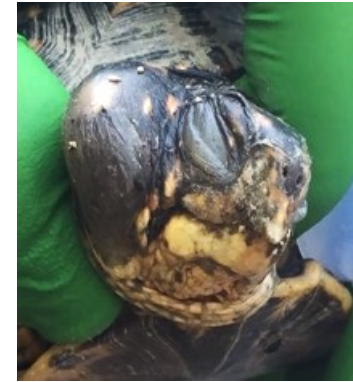
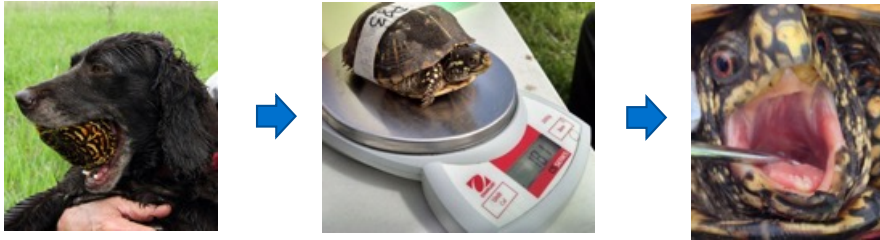


Investigating the Analytical Variability and Agreement of Manual Leukocyte Quantification Methods in Eastern Box Turtles (*Terrapene carolina carolina*)

John M. Winter¹, Nicole I. Stacy¹, Laura A. Adamovicz¹ and Matthew C. Allender^{1*}



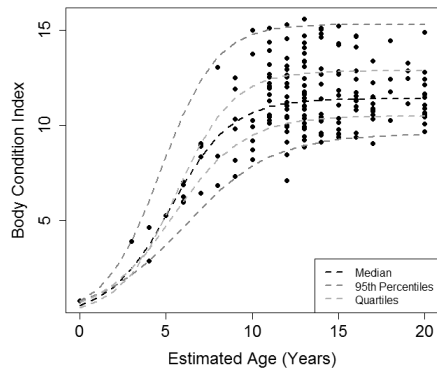
North American Box Turtles



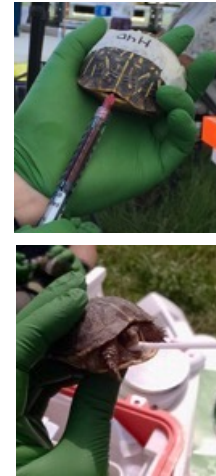
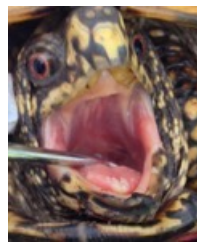
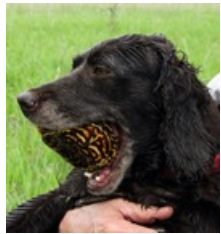
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BODY CONDITION OF EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) EVALUATED BY COMPUTED TOMOGRAPHY

Suzette de Perrot, D.V.M., M.S., Matthew C. Allender, D.V.M., M.S., Ph.D., Dipl. A.C.Z.M., Michael J. Drolich, Ph.D., Laura Adamovitz, D.V.M., Christopher A. Phillips, Ph.D., Brittany Willeford, D.V.M., Lauren Kane, D.V.M., M.S., Stephen Jostyn, B.Sc., B.V.M.S., Dipl. E.C.V.D., and Robert T. O'Brien, D.V.M., Dipl. A.C.V.R.

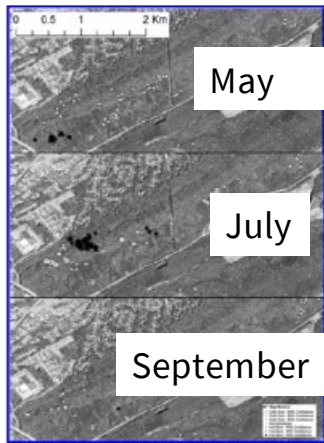


North American Box Turtles



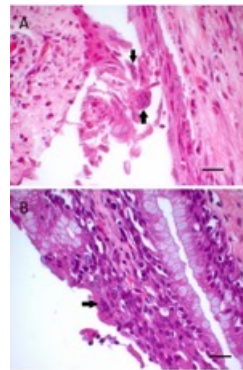
PREVALENCE OF TERRAPENE HERPESVIRUS 1 IN FREE-RANGING EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) IN TENNESSEE AND ILLINOIS

Lauren P. Kane,^{1,2} Matthew C. Allender,¹ Grace Archer,¹ Elena Dzhaman,¹ John Paulley,² A. Russell Moore,² Marilyn O. Ruiz,² Rebecca L. Smith,² John Byrd,² and Christopher A. Phillips²



Coxiella burnetii in 3 Species of Turtles in the Upper Midwest, United States

William E. Sander, Richard King, William Graser, Joshua M. Kapfer, Aubrey I. Engel, Laura Adamovicz, Matthew C. Allender



Identification of a novel herpesvirus in captive Eastern box turtles (*Terrapene carolina carolina*)

Richard R. Sim^{1,2}, Terry M. Norton³, Ellen Bronson³, Matthew C. Allender¹, Nancy Steedman⁴, April L. Childress⁵, James F.X. Wellehan Jr⁶

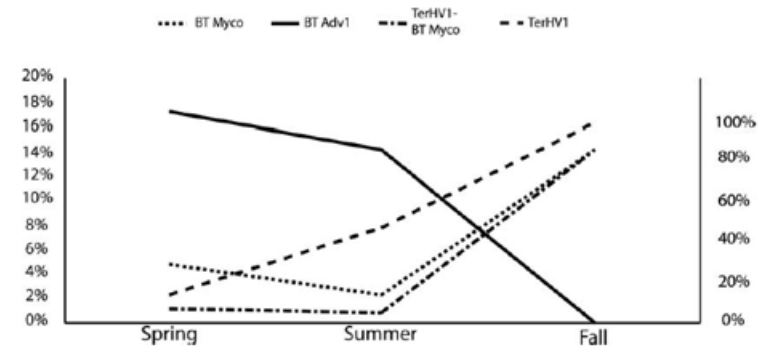
PREVALENCE AND ANTIMICROBIAL RESISTANCE PATTERNS OF *SALMONELLA* SPP. IN TWO FREE-RANGING POPULATIONS OF EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*)

Gracia Dodson, BS, Brian Garton, BS, Katy Klein, BS, Carol W. Maddox, MS, PhD, Laura A. Adamovicz, DVM, PhD, and Matthew C. Allender, DVM, MS, PhD, DACZM

Sample ID	Year	Location	Strain type	Serovar	Salmonella formula
13-123	2013	Vernon County, IL	B1	<i>Salmonella enterica</i> subsp. <i>enterica</i> serovar Anatum	3,10[10]13,34[2]b:1,6
13-239	2013	Vernon County, IL	C1	<i>S. enterica</i> serovar Thompson	6,7,14k:1,5
13-327	2013	Price Ridge, TN	C1	<i>S. enterica</i> serovar Bareilly	6,7,14y:3,5
13-330	2013	Price Ridge, TN	C2	<i>S. enterica</i> serovar Newport	6,8,20:ab:1,2[2],d
13-433	2013	Vernon County, IL	C1	<i>S. enterica</i> serovar Hartford	6,7,9aa:A[2],d
13-439	2013	Vernon County, IL	C2	<i>S. enterica</i> serovar Newport	6,8,20:ab:1,2[2],d
18-1226	2018	Vernon County, IL	B1	<i>S. enterica</i> serovar Anatum	3,10[10]13,34[2]b:1,6
18-1710	2018	Matton County, IL	C1	<i>S. enterica</i> serovar Bareilly	6,7,14y:3,5
18-1754	2018	Matton County, IL	C1	<i>S. enterica</i> serovar Hartford	6,7,9aa:A[2],d

DETECTION OF COPATHOGENS IN FREE-RANGING EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) IN ILLINOIS AND TENNESSEE

Grace A. Archer, DVM, Christopher A. Phillips, Ph.D., Laura Adamovicz, DVM, Mark Band, Ph.D., John Byrd, M.S., and Matthew C. Allender, DVM, M.S., Ph.D., Dipl. A.C.Z.M.





North American Box Turtles

Category	Number of Parameters	Parameters
Identification	3	Permanent ID, Lab ID, Temporary ID
Capture	21	Search purpose, outcome, condition, finder (canine vs human), date, time, time of capture, time of release, year, season, state, site, air temperature, latitude, longitude, body temperature at capture, wind, humidity, habitat, sky conditions, substrate, substrate temperature
Morphometrics	14	Recapture sex, age class, mass, annuli estimate, annuli definition, length, annuli
Physical exam	>180	Body temperature, tympanum, carapace, mucous membrane color, nasal discharge, ocular plaque, heart rate
Clinical pathology		Neutrophils, eosinophils, calcium, phosphorus, aspartate aminotransferase, alanine aminotransferase
Pathogens	10	FV3, BIV, EHNV, AIV, terrapene herpesvirus 1, Terrapene herpesvirus 2, emydid Mycoplasma, tortoise intranuclear coccidiosis, box turtle adenovirus, Mycoplasma agassizii, Mycoplasma testudineum, chytrid (both), Borrelia, Anaplasma
Ancillary diagnostics	31	Acute phase proteins, protein electrophoresis, blood gasses, heavy metal toxicology, intraocular pressure, tear production

CHELONIAN HEALTH ASSESSMENT DATA SHEET

Capture Data Surveillance Outbreak Released Hosp

Alive Fresh Dead Carapace only Plastron Only Complete Shell

TemporaryID: _____ Latitude: _____
 Species: _____ Longitude: _____
 Date: 5/17/2019 BodyTemp@Capture: _____
 Time of Capture: _____ Time of Release: _____
 Year: _____ UV: _____
 Season: Spring Summer Fall Wind: 0 1 2 3 4
 State: Illinois Tennessee Humidity: 0 1 2 3 4
 Location: _____
 AirTemp: _____

Natural History

Recapture Yes No Straight Carapace Length: _____
 Sex: Male Female Unknown Straight Carapace Width: _____
 AgeClass: Adult Juvenile Straight Carapace Height: _____
 Weight: _____ Anterior Plastron Length: _____
 AnnuliEstimate: _____ Posterior Plastron Length: _____
 AnnuliDefinition: Well defined Somewhat well defined Very smooth Total Plastron Length: _____
 Somewhat smooth L post: _____

Physical Exam

PE Yes No Bright Quiet Unknown Red Pale
 Necropsy Yes No Alert Depressed Unknown Light pink Pale
 Blood Yes No Responsive Unresponsive Moist Dry
 OralSwab Yes No BCC: _____
 CloacalSwab Yes No Temperature: _____
 PlastralBark Yes No Diarrhea Yes No Mucus membrane: _____
 CBC Yes No Enteroliths Yes No Moist Dry
 Biochem Yes No Nasals WNL NE Symmetrical Asym
 EPH Yes No Integument WNL NE Flaking Swelling Com
 BloodGas Yes No Tympanum WNL NE Aural abscess Com
 APP Yes No Carapace WNL NE Flaking Predator inj
 Tox Yes No Plastron WNL NE Flaking Predator inj
 Disease Yes No Appendages WNL NE Missing digits Missin
 Radiograph Yes No Cloaca WNL NE Flaking Swelling Missin
 Ultrasound Yes No Ungeatal WNL NE Eggs present Phallu
 Endocrinology Yes No Venipuncture Time: _____

DESIGNED BY WILDLIFE EPIDEMIOLOGY LAB, UNIVERSITY OF ILLINOIS, COPYR

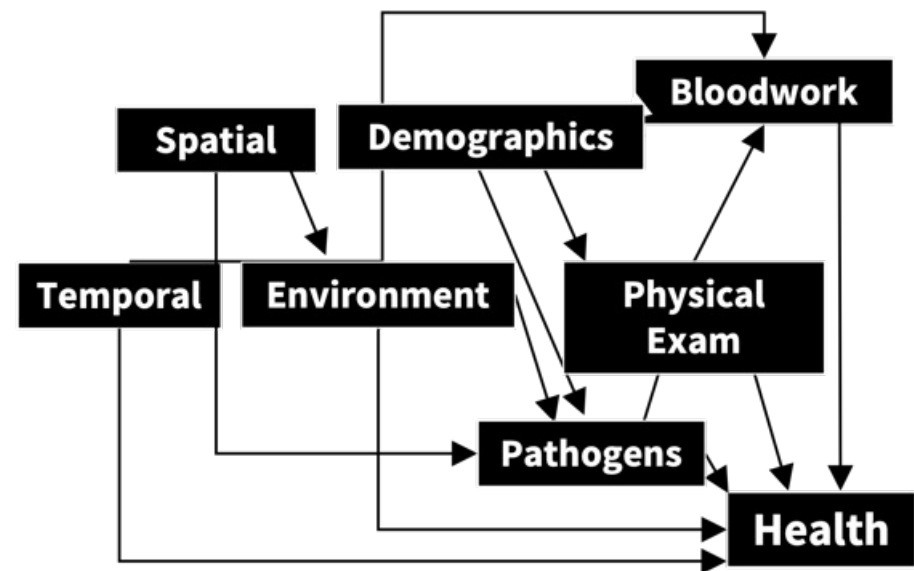
Health Assessment of Wild Eastern Box Turtles (*Terrapene carolina carolina*) in East Tennessee

Brittany M. Way Rose, BS, Matthew C. Allender, DVM, MS, PhD, DACZM

North American Box Turtle Health



- Perform multi-faceted, integrated health assessments
 - Physical examination
 - Morphometrics
 - Hematology
 - Plasma Biochemistry
 - Infectious Disease Testing



Ranavirus

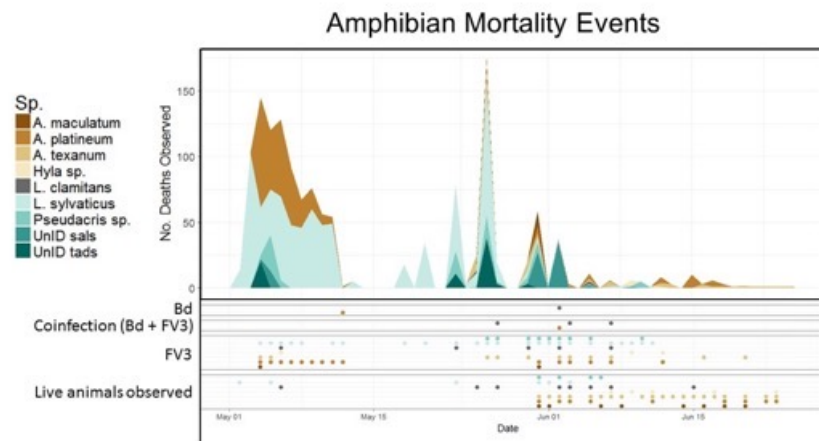
- Viral Characteristics
 - ds DNA virus
 - Temperature dependent, cannot survive >31C
- Epidemiology
 - Box turtles uniquely sensitive
 - >90% mortality





Ranavirus

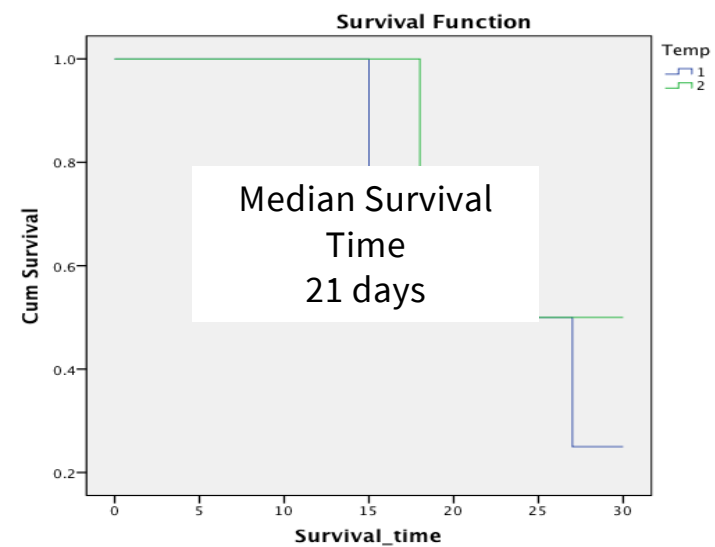
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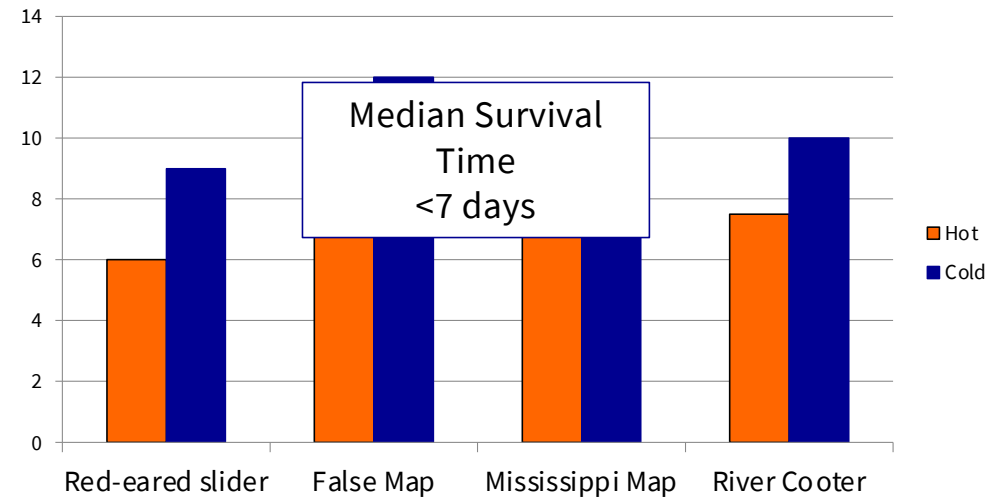


Ranavirus



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Median Survival Time (d) in Ranavirus Infected Turtles





Ranavirus

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 - >90% mortality
 - Minimal hematologic response

Hematologic Response to Experimental Infections of Frog Virus 3-Like Virus in Red-Eared Sliders (*Trachemys scripta elegans*)

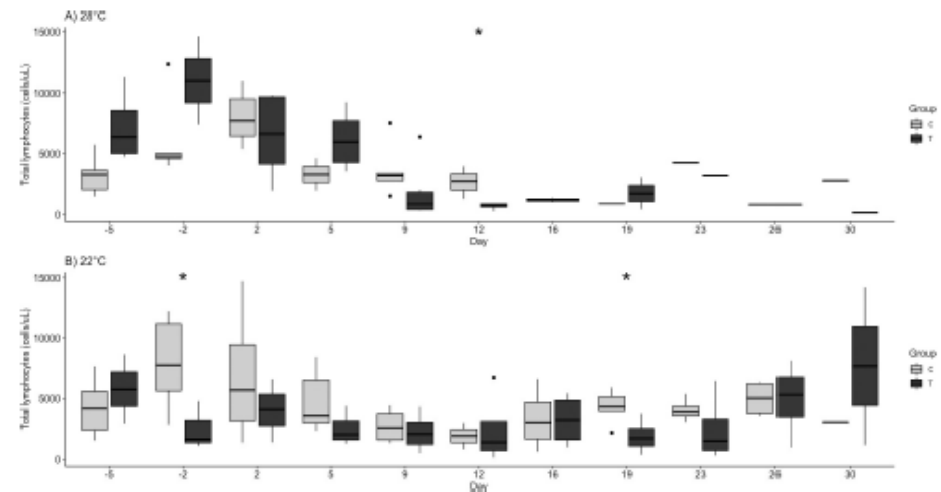
Matthew C. Allender^{1,2}, DVM, MS, PhD, DACZM,
Mark A. Mitchell², DVM, MS, PhD, DECZM (Herpetology)

TS*	Pre-inoculation	3.8	2.8	4.7	2.3	5
(g/dl)	Postinoculation	3.8	2.6	5	2	5
	Terminal	2.1	1.4	2.9	1	3

Ranavirus



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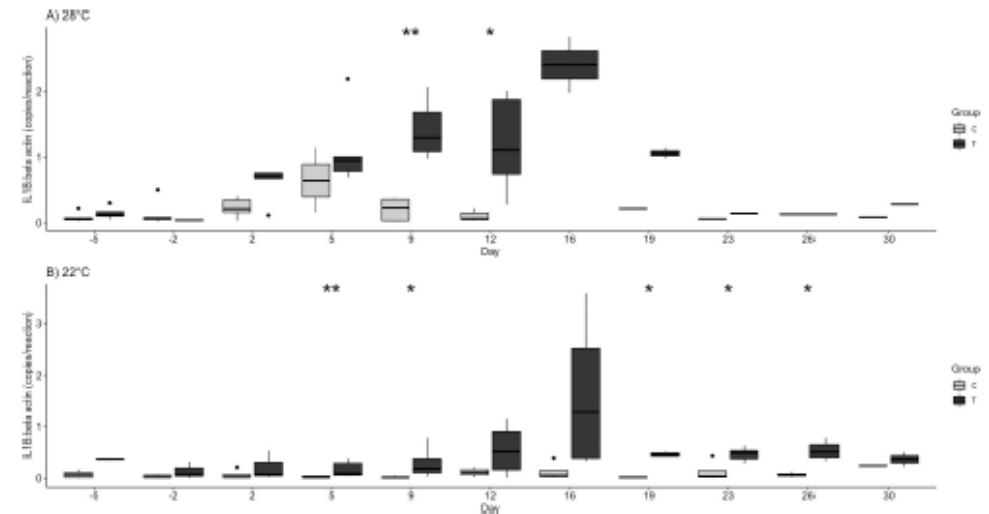
Temperature affects the host hematological and cytokine response following experimental ranavirus infection in red-eared sliders (*Trachemys scripta elegans*)

Jeremy M. Rayl¹, Matthew C. Allender



Ranavirus

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 - Cytokine storm leading to death



Temperature affects the host hematological and cytokine response following experimental ranavirus infection in red-eared sliders (*Trachemys scripta elegans*)

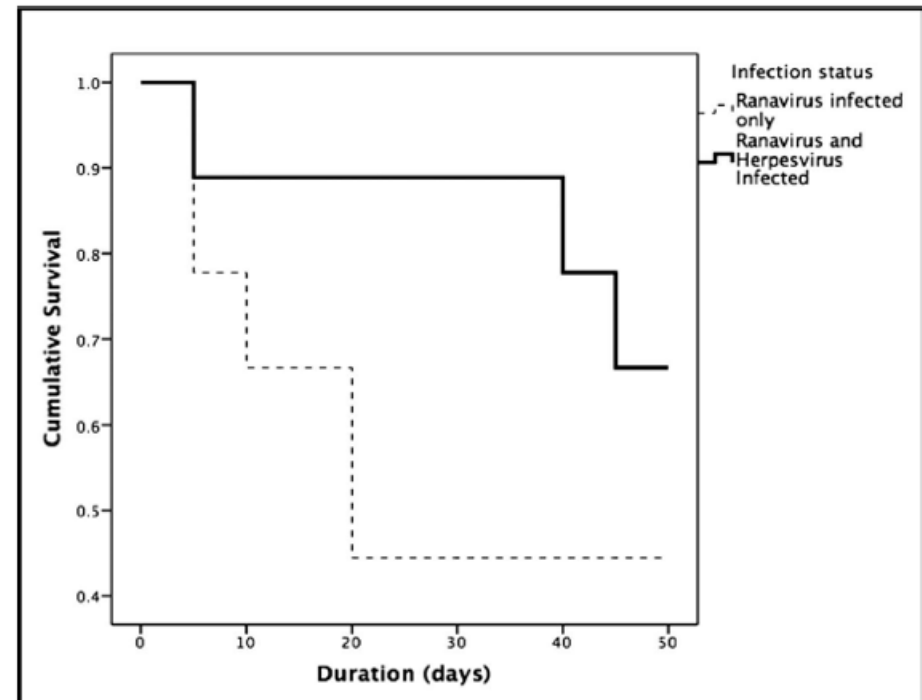
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 - Cytokine storm leading to death
 - Co-infections may alter ranavirus mortality

RANAVIRUS EPIZOOTIC IN CAPTIVE EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) WITH CONCURRENT HERPESVIRUS AND MYCOPLASMA INFECTION: MANAGEMENT AND MONITORING

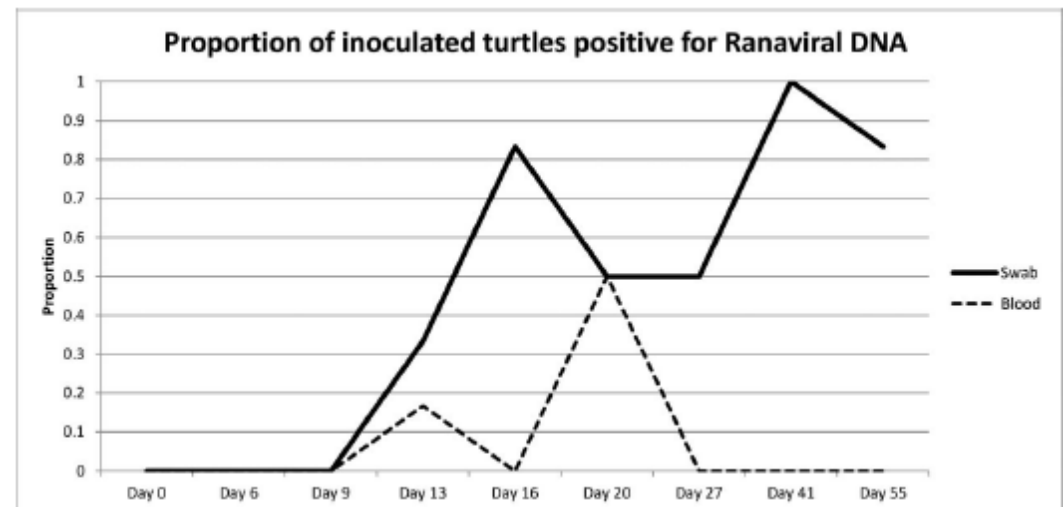
Richard R. Sim, D.V.M., Matthew C. Allender, D.V.M., Ph.D., Dipl. A.C.Z.M., LaTasha K. Crawford, V.M.D., Ph.D., Allison N. Wack, D.V.M., Kevin J. Murphy, B.S., Joseph L. Mankowski, D.V.M., Ph.D., Dipl. A.C.V.P., and Ellen Bronson, med. vet., Dipl. A.C.Z.M.



Ranavirus



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 - Co-infections may alter ranavirus mortality
 - Survival confers reservoir status



EXPERIMENTAL CHALLENGE STUDY OF FV3-LIKE RANAVIRUS INFECTION IN PREVIOUSLY FV3-LIKE RANAVIRUS INFECTED EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) TO ASSESS INFECTION AND SURVIVAL

Jennifer C. Hausmann, D.V.M., Allison N. Wack, D.V.M., Matthew C. Allender, D.V.M., Ph.D., Dipl. A.C.Z.M., Mike R. Cranfield, D.V.M., Kevin J. Murphy, B.S., Kevin Barrett, B.S., Jennell L. Romero, D.V.M., James F. X. Wellehan, D.V.M., Ph.D., Dipl. A.C.Z.M., Dipl. A.C.V.M. (Virology, Bacteriology/ Mycology), Stella A. Blum, B.S., M. Christine Zink, D.V.M., Ph.D., Dipl. A.C.V.P., and Ellen Bronson, med. vet., Dipl. A.C.Z.M.

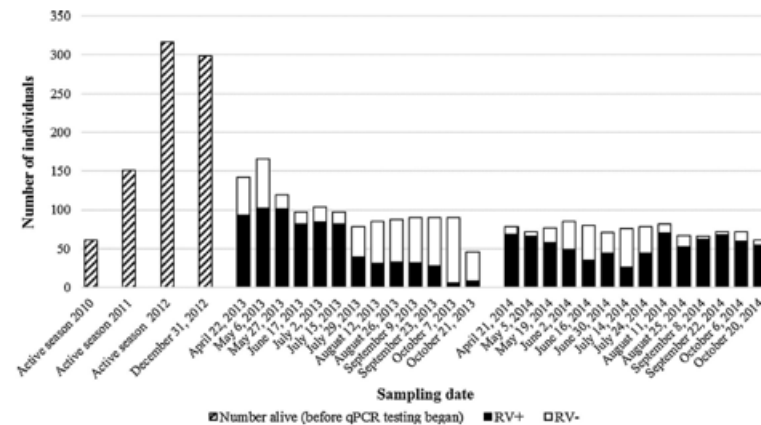


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 - Survival confers reservoir status
- Conservation Concern
 - Primary pathogen of concern for release

A Severe *Ranavirus* Outbreak in Captive, Wild-Caught Box Turtles

Steven J. A. Kimble,¹ April J. Johnson,² Rod N. Williams,¹ and Jason T. Hoverman¹



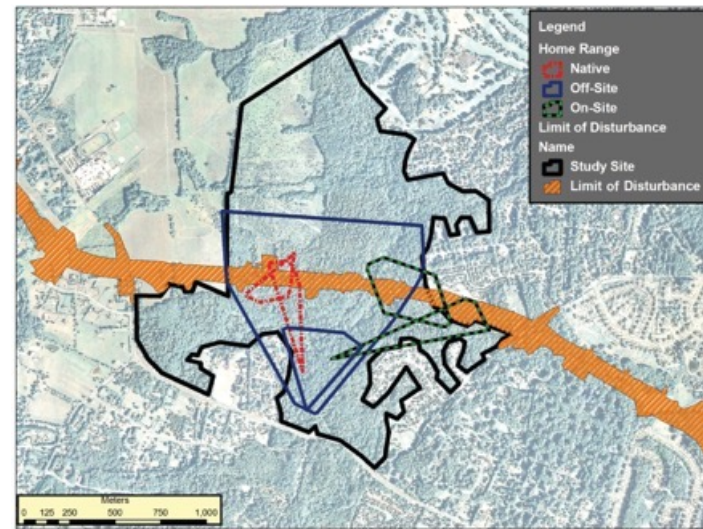
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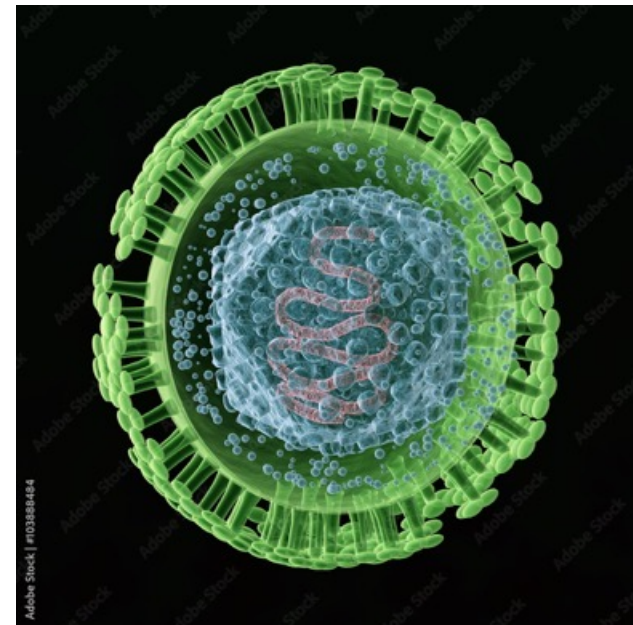
Responses, Movements, and Survival of Relocated Box Turtles During Construction of the Intercounty Connector Highway in Maryland

Scott D. Farnsworth and Richard A. Seigel



Herpesviruses

- Viral Characteristics
 - ds DNA virus
 - Doesn't survive well outside body





Herpesviruses

- Viral Characteristics
 - ds DNA virus
 - Doesn't survive well outside body
- Epidemiology
 - Each turtle has uniquely distinct herpes

Variable	Individual EBHV1 prevalence (%)	
	2017	2018
Site		
SBCP	10/32 (31.3%)	11/98 (11.2%)
IBSP	7/29 (24.1%)	5/47 (10.6%)
Age		
Adult	17/54 (31.5%)	15/79 (19.0%)
Subadult	0/2 (0%)	0/43 (0%)
Juvenile	0/5 (0%)	1/23 (4.3%)
Sex		
Female	14/51 (27.5%)	14/79 (17.7%)
Male	3/10 (30%)	2/35 (5.7%)
Unknown	0/0 (0%)	0/31 (0%)
Month		
May	16/49 (32.7%)	15/67 (22.4%)
June	0/42 (0%)	0/68 (0%)
July	0/57 (0%)	0/24 (0%)
August	0/49 (2.0%)	1/1 (100%)
Total	17/61 (28%)	16/145 (11%)

EPIDEMIOLOGY OF *EMYDOIDEA* HERPESVIRUS 1 IN FREE-RANGING BLANDING'S TURTLES (*EMYDOIDEA BLANDINGII*) FROM ILLINOIS

Dana M. Lindemann, DVM, MS, Matthew C. Allender, DVM, MS, PhD, Dipl. ACZM, Dan Thompson, BS, Gary A. Glowacki, MS, Erin M. Newman, BS, Laura A. Adamovicz, DVM, and Rebecca L. Smith, DVM, MS, PhD

Herpesviruses



- Viral Characteristics
 - ds DNA virus
 - Doesn't survive well outside body
- Epidemiology
 - Each turtle has uniquely distinct herpes

Development and validation of a quantitative PCR assay for detection of *Emydoidea* herpesvirus 1 in free-ranging Blanding's turtles (*Emydoidea blandingii*)

Dana M. Lindemann^{a,*}, Matthew C. Allender^a, Dan Thompson^b, Laura Adamovicz^a, Elena Dzhaman^a

PREVALENCE OF TERRAPENE HERPESVIRUS 1 IN FREE-RANGING EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) IN TENNESSEE AND ILLINOIS

Lauren P. Kane,^{1,7} Matthew C. Allender,¹ Grace Archer,¹ Elena Dzhaman,¹ John Pauley,² A. Russell Moore,³ Marilyn O. Ruiz,⁴ Rebecca L. Smith,⁴ John Byrd,⁵ and Christopher A. Phillips⁶

Identification of a novel herpesvirus in captive Eastern box turtles (*Terrapene carolina carolina*)

Richard R. Sim^{a,*}, Terry M. Norton^b, Ellen Bronson^a, Matthew C. Allender^c, Nancy Stedman^d, April L. Childress^e, James F.X. Wellehan Jr^e

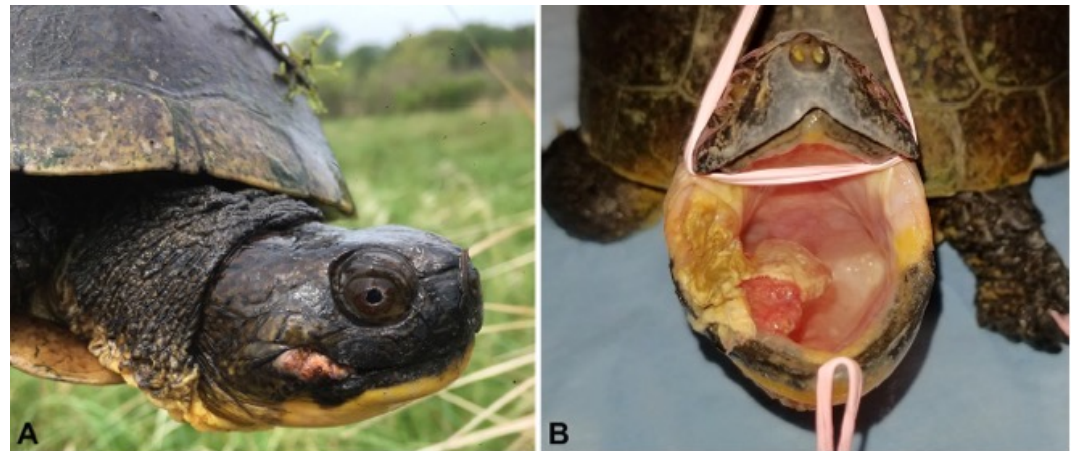
Herpesviruses in Captive Chelonians in Europe Between 2016 and 2020

Christoph Leineweber, Elisabeth Müller and Rachel E. Marschang*

Herpesviruses



- Viral Characteristics
 - ds DNA virus
 - Doesn't survive well outside body
- Epidemiology
 - Each turtle has uniquely distinct herpes
 - Novel species may cause disease

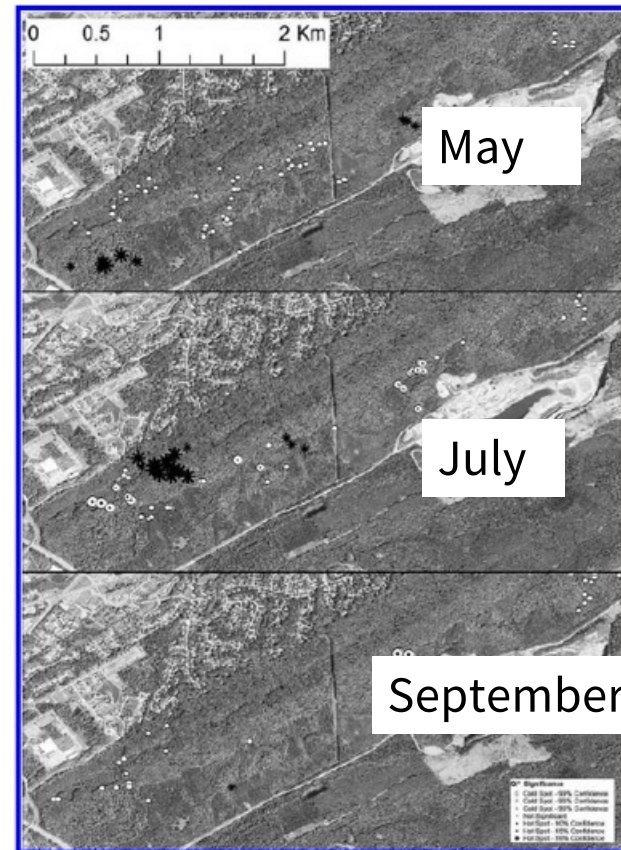


Detection of a novel herpesvirus associated with squamous cell carcinoma in a free-ranging Blanding's turtle

Kirsten E. Andersson, Laura Adamovicz, Lauren E. Mumm, John M. Gary, Gary Glowacki, Rachel Teixeira-Neto, Michael J. Adkesson, Eric T. Ho, Ellen Haynes, Matthew C. Allender¹

Herpesviruses

- Viral Characteristics
 - ds DNA virus
 - Doesn't survive well outside body
- Epidemiology
 - Each turtle has uniquely distinct herpes
 - Novel species may cause disease
 - Host-adapted herpes have unknown significance
 - Prevalence seasonally distinct
- Conservation Concern
 - Release should occur with turtles in a similar plane of health to recipient population



PREVALENCE OF TERRAPENE HERPESVIRUS 1 IN FREE-RANGING EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) IN TENNESSEE AND ILLINOIS

Lauren P. Kane,^{1,2} Matthew C. Allender,¹ Grace Archer,¹ Elena Dzhaman,¹ John Pauley,² A. Russell Moore,¹ Marilyn O. Rutz,¹ Rebecca L. Smith,¹ John Byrd,² and Christopher A. Phillips¹

Mycoplasma/Mycoplasmosis



- Bacterial Characteristics
 - Intracellular bacteria
 - Doesn't survive well outside body, difficult to culture

Mycoplasma agassizii Causes Upper Respiratory Tract Disease in the Desert Tortoise†

MARY B. BROWN,^{1*} ISABELLA M. SCHUMACHER,² PAUL A. KLEIN,³ KEITH HARRIS,⁴ TERRIE CORRELL,⁵ AND ELLIOTT R. JACOBSON²



Mycoplasma/Mycoplasmopsis



- Bacterial Characteristics
 - Intracellular bacteria
 - Doesn't survive well outside body, difficult to culture
- Epidemiology
 - Shared Mycoplasma species among emydid
 - All can lead to disease/mortality

A *Mycoplasma* Species of Emydidae Turtles in the Northeastern USA

Robert J. Ossiboff,^{1,5} Bonnie L. Raphael,¹ Alyssa D. Ammazalorso,^{1,2} Tracie A. Seimon,¹ Holly Niederriter,³ Brian Zarate,⁴ Alisa L. Newton,¹ and Denise McAloose¹ ¹Wildlife Conservation Society, Zoological Health Program, 2300 Southern Boulevard, Bronx, New York 10460, USA; ²Fordham University, 441 East Fordham Road, Bronx, New York 10458, USA; ³Division of Fish and Wildlife, Delaware Department of Natural Resources and Environmental Control, 4876 Hay Point Landing Road, Smyrna, Delaware 19977, USA; ⁴New Jersey Division of Fish and Wildlife Endangered and Nongame Species Program, 1 Van Syckles Road, Clinton, New Jersey 08809, USA; ⁵Corresponding author (email: rjo23@cornell.edu)

A NOVEL MYCOPLASMA DETECTED IN ASSOCIATION WITH UPPER RESPIRATORY DISEASE SYNDROME IN FREE-RANGING EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) IN VIRGINIA

Sanford H. Feldman,¹ Jeffrey Wimsatt,^{1,2,8} Rachel E. Marchang,³ April J. Johnson,⁴ William Brown,⁵ Joseph C. Mitchell,⁶ and Jonathan M. Sleeman⁷

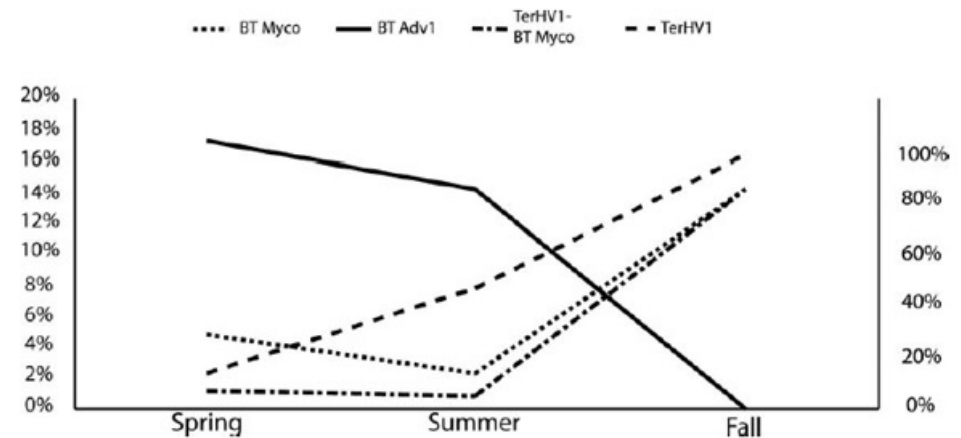


Mycoplasma/Mycoplasmosis

- Bacterial Characteristics
 - Intracellular bacteria
 - Doesn't survive well outside body, difficult to culture
- Epidemiology
 - Shared Mycoplasma species among emydid
 - All can lead to disease/mortality
 - Possibly seasonal
- Conservation Concern
 - Release should occur with turtles in a similar plane of health to recipient population

DETECTION OF COPATHOGENS IN FREE-RANGING EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) IN ILLINOIS AND TENNESSEE

Grace A. Archer, D.V.M., Christopher A. Phillips, Ph.D., Laura Adamovicz, D.V.M., Mark Band, Ph.D., John Byrd, M.S., and Matthew C. Allender, D.V.M., M.S., Ph.D., Dipl. A.C.Z.M.



Adenoviruses

- Viral Characteristics
 - ds DNA
- Epidemiology
 - Large host and virus diversity
 - Many unknowns
 - Possibly seasonal



PREVALENCE OF BOX TURTLE ADENOVIRUS IN EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) PRESENTED TO A WILDLIFE REHABILITATION CENTER IN VIRGINIA, USA

Dana Franzen-Klein, DVM, MS, Laura Adamovicz, DVM, PhD, David McRuer, MSc, DVM, Dipl ACVPM, Stella A. Carroll, DVM, James F. X. Wellehan, DVM, MS, PhD, Dipl ACZM, Dipl ACVM, and Matthew C. Allender, DVM, MS, PhD, Dipl ACZM

HEALTH ASSESSMENT OF PAINTED TURTLES (*CHRYSEMYS PICTA*) IN A RESTORED WETLAND HABITAT IN NORTHWESTERN INDIANA, USA

Emily C. Vincent,^{1,2,7} Melissa A. Fayette,² John A. Griffioen,^{2,3} Garet Litwiler,⁴ Laura Adamovicz,⁵ Emilie Ospina,⁵ and Matthew C. Allender^{5,6}



Adenoviruses

- Viral Characteristics
 - ds DNA
- Epidemiology
 - Large host and virus diversity
 - Many unknowns
 - Possibly seasonal
- Conservation Concern
 - Release should occur with turtles in a similar plane of health to recipient population
 - Need to survey for novel species

PREVALENCE OF BOX TURTLE ADENOVIRUS IN EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) PRESENTED TO A WILDLIFE REHABILITATION CENTER IN VIRGINIA, USA

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Turtle characteristics	BTAdV Positive	BTAdV Negative
Rehabilitation	58	37
Wild caught	1	10
Adult	58	46
Juvenile	1	1
Male	34	28
Female	24	18
Unknown	1	1
Trauma	47	31
Infectious	9	3
Other	2	3
Clinically healthy	1	10
Euthanized or died	39	26
Released or transferred to captivity	20	21

Adenoviruses



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 - Large host and virus diversity
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PREVALENCE OF BOX TURTLE ADENOVIRUS IN EASTERN BOX TURTLES (*TERRAPENE CAROLINA CAROLINA*) PRESENTED TO A WILDLIFE REHABILITATION CENTER IN VIRGINIA, USA

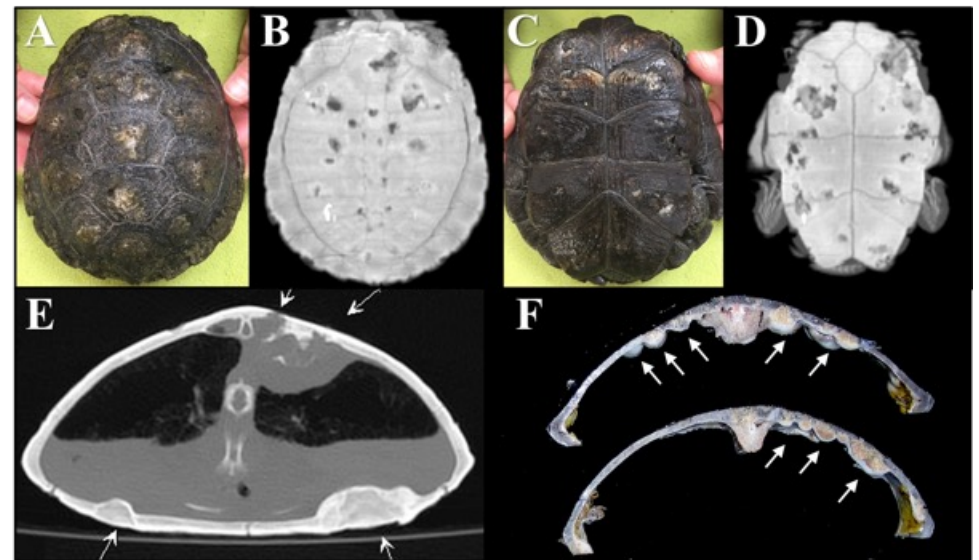
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Admission date	Age	Sex	Cause of admission	Number of viral copies detected/ng	Outcome
11-Sep-15	Adult	Female	Trauma: chronic fractures with secondary infection	216,858	Euthanized 48 hr after admission
15-Sep-15	Adult	Female	Trauma: dog interaction	612	Released 17-Sept-15
1-Jun-16	Adult	Male	Trauma: severe shell fractures	39,108	Euthanized on admission
5-Jun-16	Adult	Male	Trauma: severe skull fractures	977	Euthanized on admission
7-Jun-16	Adult	Female	Trauma: forelimb amputation and bridge fracture	1,616	Released 6-Aug-16
16-Jun-16	Adult	Female	Infectious: bilateral aural abscesses	104,489	Released 9-Aug-16
23-Jun-16	Adult	Male	Trauma: severe shell fractures	1,817	Euthanized 24 hr after admission

Emydomyces



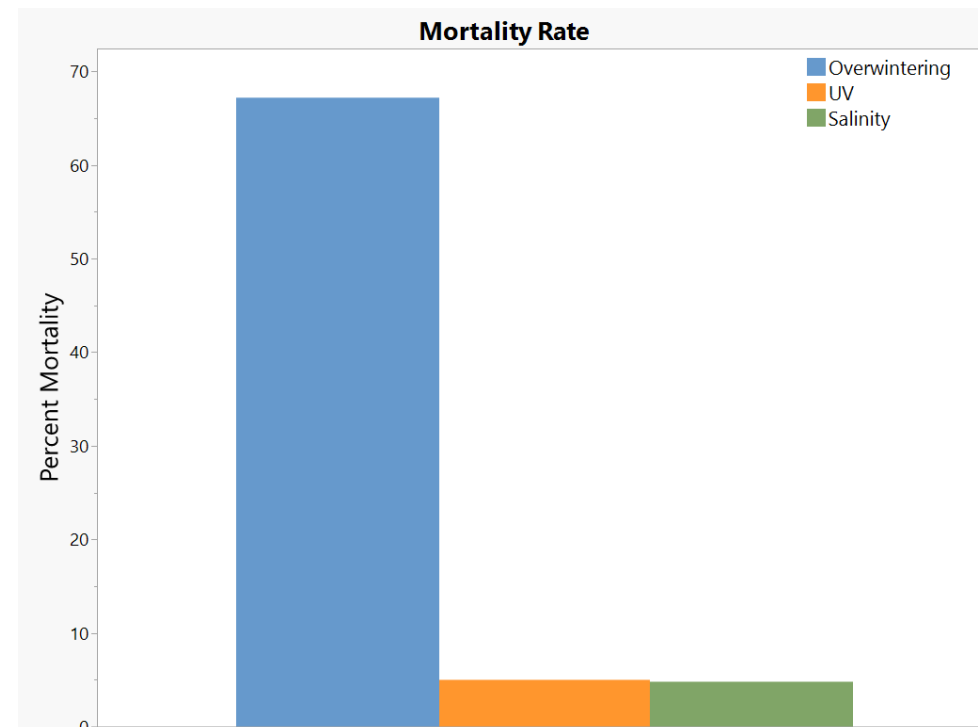
- Fungal Characteristics
 - Onygenalean fungi
 - Keratinophilic
- Epidemiology
 - Large host diversity
 - Many unknowns





Emydomyces

- Fungal Characteristics
 - Onygenalean fungi
 - Keratinophilic
- Epidemiology
 - Large host diversity
 - Many unknowns
- Conservation Concern
 - Do not release positive individuals





Confiscation events

- 2021
 - 96 turtles initially → New England Aquarium, New England Zoo, and Roger Williams Park Zoo
 - 40 turtles died prior to disease testing results (42%)

Co-infection	Number of turtles	Prevalence
FV3-TerHV1-Myco-TerAdv1	20	57%
FV3-TerHV1-Myco	4	14%
FV3-TerAdv1-Myco	1	3%
FV3-Myco	6	17%
Myco-TerHV1	3	9%



Confiscation events

- 2021 – Confiscation 1
 - 56 remaining turtles sent to WEL
 - Intake testing of 24 pathogens using qPCR and 3 pathogen classes using conventional PCR and sequencing
 - Results
 - 8 different pathogens
 - FV3
 - Mycoplasma
 - TerHV1, 2, and 3
 - Chlamydia
 - Leptospirosis
 - Terrapene adenovirus (Europe)

Confiscation events



- 2021
 - All turtles survived to brumation and buried on their own
 - No turtles emerged by May 2022
 - All had died naturally at various states of decomposition
 - Rare (n=5) tissues positive for FV3, but severe autolysis
 - Conclusions
 - 100% mortality
 - Complex disease pattern upon presentation

Confiscation events



- 2022 – Confiscation 2
 - Seventeen eastern box turtles sent to WEL
 - Subset of individuals (n=7) were positive for FV3

Confiscation Event



Variable shedding over time

- Mycoplasma: 27-71% positive over 12 months, highest in November
- Terrapene herpesvirus 1: 0-90% positive over 12 months, highest in May
- Box turtle adenovirus: 0-45% positive over 12 months, highest in April

Clinical signs not associated with pathogen status

Future Directions and Conservation Outcomes



- Ranavirus and other co-pathogens continue to be a concern for success of re-introductions of confiscations
- Need to assess potential for pathogen recurrence and transmission
 - Different temperatures
 - Impact of anti-inflammatory therapy
 - Role of co-pathogens
- Novel or existing pathogens of concern
 - Emydomcyes
 - Fraservirus
 - Others

Future Directions and Conservation Outcomes



- Single pathogen surveys are insufficient
 - Likely more than 3-4 pathogens will impact release and recovery efforts
 - Surveying for existing and novel pathogens is critical
 - Surveillance to recipient populations is crucial to success
- Released turtles should be followed for outcome status
- Pathogens may cause more than mortality, subclinical impacts on nutrition and reproduction are possible



Thank You

