# RESEARCH SPOTLIGHT

# SACNAS

2018 - 2019

VOLUME 1

# What is SACNAS?

The Society Advancing Chicanos/Hispanics & Native Americans in Science (SACNAS) is a national organization that strives to increase the diversity of scientists in professional fields, in obtaining advanced degrees and careers, and serving in positions of leadership.

Illinois State University (ISU) SACNAS chapter goals:

1. Expand access to research and professional development.
2. Increase awareness of and commitment to STEM diversity.
3. Build a community of diverse professionals and advocates across scientific fields.

While SACNAS targets students from underserved communities, **all students** are encouraged to participate and to help build an inclusive experience at ISU.

# Why the Spotlight?

The SACNAS *Research Spotlight* is a collaborative science communication project. We hope to highlight student-driven research and promote scientific literacy in our community. The publications that we have highlighted contain brand new research coming out of ISU. Our goals are to make the research happening here on campus as accessible as possible while also highlighting the students who have worked so hard to make it happen. It's important to remember that this research is conducted by real people across campus. The students who have participated in the *Research Spotlight* have gained valuable skills in science communication, and we hope that their efforts motivate people to learn more about science and help them better understand the world around us.

So, whether you're a first-year student, a graduate student, or haven't seen a science class for many years, we hope that you'll read along with us and discover the exciting research being explored at ISU. If you are interested in becoming involved in research on campus or participating in the SACNAS *Research Spotlight*, please reach out to SACNAS for information (sacnas.isu@gmail.com)!

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# Hormones and embryos: Understanding steroid metabolism in European starling eggs



**Featured Scientist:** Nicole A. Campbell, M.S. 2019, School of Biological Sciences

**Birthplace:** Joliet, IL

**My Research:** I am fascinated by the process of **embryonic development**. As an **embryo** develops, it is critical that the correct **hormones** are expressed at the right times to ensure that the **embryo** is healthy. My work focuses on **embryos** of the European starling, but my research can also help us to understand human systems. People used to think that **hormones** directly affect an **embryo** as it grows and develops, but this idea is at odds with what we know about how these **hormones** are broken down in the body. As an **embryo** grows, **hormones** are quickly processed through metabolism. With the help of my adviser Dr. Paitz, I examined a different idea: that the effects of **hormones** are driven by their **metabolites**.

**Research Goals:** I hope to continue research in the future by working with animal breeding programs to help endangered species.

**Career Goals:** I want to have a career where I can apply science to help breed and restore endangered animal species. I am hopeful that this work will help me transition to a career where I get to work directly with endangered species, like the red panda.

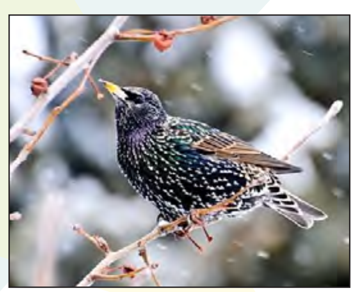
**Hobbies:** I love crafting cute projects that I find on Pinterest and managing my dog's Instagram page.

**Favorite Thing About Science:** My favorite thing about science is being able to visually see things, like **embryos**, while they are developing. I get to see natural processes in person. It's pretty amazing how something so small can contain all of the information about how an animal develops.

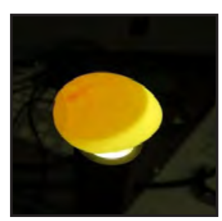
**Organism of Study:** European starling

**Field of Study:** Comparative Endocrinology

**What is Comparative Endocrinology?**
Comparative Endocrinology is the study of **hormones** and their effects on various aspects of development in animals. My



*Adult European starling*



*European starling egg/ **embryo***

# Hormones and embryos: Understanding steroid metabolism in European starling eggs

research uses animal models to test the effects of different **hormones**, which can inform us about their roles in the human body.

**Check Out My Original Paper:** "Characterizing the timing of yolk testosterone metabolism and the effects of etiocholanolone on development in avian eggs"

**Citation:** **N.A. Campbell**, R.A. Angles, R.M. Bowden, J.M Casto, R.T. Paitz, Characterizing the timing of yolk testosterone metabolism and the effects of etiocholanolone on development in avian eggs. *J. Exp. Biol.* 223.4: (2020).

**Research at a Glance:** When birds lay eggs, the **yolk** contains both **hormones** and nutrients for the developing **embryo**. In this paper, I investigated how starlings break down **hormones** in the egg. I also studied important **metabolites** of this breakdown and conducted tests to see if the **metabolites** affected **embryonic** growth.

It's important to know how long specific **hormones** remain in an **embryo**. If we know how long a **hormone** is present, then we can determine whether or not it will influence the **embryo**. In this study, we looked at the **hormone testosterone**, to see how quickly it breaks down during early development in starling **embryos**. Surprisingly, we found that most of the **testosterone** is broken down within just a few hours. This result raised another question: how does **testosterone** affect the **embryo** if it is broken down so rapidly?

We guessed that **testosterone** may affect the **embryo's** secondary **metabolites**. Secondary **metabolites** are the products that are made when **hormones** are broken down. Our work showed that these **metabolites** stick around inside the egg **yolk** much longer than **testosterone**. We set out to see if these **metabolites** affect the growth of the **embryo**. We injected extra amounts of a secondary **metabolite**, **etiocholanolone**, into the eggs. Our results did not show that extra **etiocholanolone** affected **embryonic development**. One explanation for our results is that there was already **etiocholanolone** present in the eggs.

**Highlights:** I think the most important step for my research is the study that we did on ***in ovo*** **testosterone** metabolism. We performed this experiment over the course of two laying seasons. In the first season, we gathered 38 freshly laid starling eggs from our study site and took eggs from 36 different **clutches**. We purchased a **radiolabeled** form of **testosterone** that would allow us to keep track of **testosterone** levels as the

# Hormones and embryos: Understanding steroid metabolism in European starling eggs



embryos grew. We injected each egg with testosterone mixed with sesame oil. The oil was used to keep the injection of the radiolabeled testosterone in one spot near the embryo. We did this so that the testosterone could diffuse from that central area into the embryo. Then, each egg was allowed to grow for different lengths of time in an incubator. The period of time that the eggs were allowed to grow was assigned randomly.

Next, we wanted to see what happened to the testosterone. We removed the eggs from the incubator, froze them, and separated the egg into two parts: the yolk and albumen. We weighed each part, then separated out the hormones. We were able to isolate the hormones using two techniques: solid phase extraction and column chromatography. Finally, we put the samples through a scintillation counter. The scintillation counter helped us test which metabolites had our radiolabel on them. By figuring out which metabolites had our radiolabel, we could tell how much of the testosterone we injected had broken down.

When we repeated this experiment in the second season, we used more testosterone for our injections and shortened the length of time that eggs were allowed to grow. We sampled embryos within a 12-hour window. We also mixed the yolk with the albumen when we sampled and used a yolk/albumen mix to extract hormones.

Our results show that after incubation starts, the testosterone in the egg breaks down quickly. This means that testosterone probably does not directly affect how the embryos develop. Instead, we think that the testosterone metabolites are responsible.

**What My Science Looks Like: Figures 1-3** show the results of my experiment from the second season, where we added to testosterone to the eggs and tracked how testosterone was broken down over the course of 12 hours. Each figure shows the average radioactivity on the y-axis. This tells us how much of the testosterone or metabolite is found in the yolk/albumen mixture.

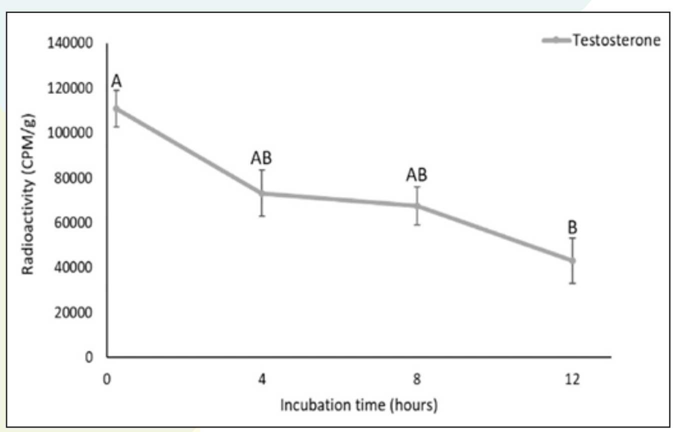



**Figure 1**. The amount of testosterone in the embryo after 12 hours of incubation. *Figure adapted from Campbell et al. 2020.*

We looked at testosterone and two of its metabolites, androstenedione and etiocholanolone. In **Figure 1**, we see that

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the amount of **testosterone** in the eggs is rapidly dropping over time. In **Figure 2** and **Figure 3**, both **androstenedione** and **etiocholanolone** start to increase after only 4 hours of **incubation**. The fact that they both show up so early indicates that **testosterone** is being broken down quickly once the egg is incubated.

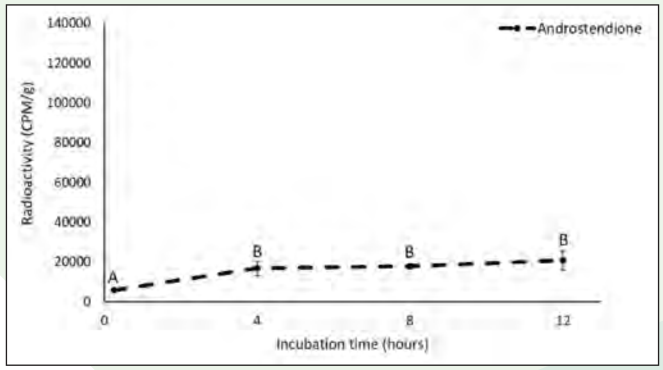



**Figure 2**. The amount of **androstenedione**, a **testosterone metabolite**, in the **embryo** after 12 hours of **incubation**. *Figure adapted from Campbell et al. 2020.*

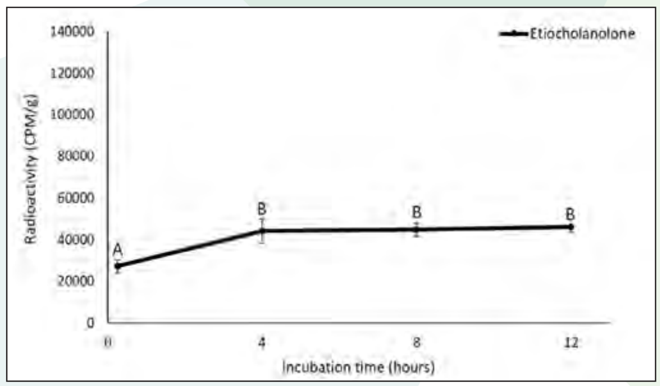



**Figure 3**. The amount of **etiocholanolone**, a **testosterone metabolite**, in the **embryo** after 12 hours of **incubation**. *Figure adapted from Campbell et al. 2020.*

**The Big Picture:** We show that **testosterone metabolites** are present near the **embryo** before many key processes begin. We put forth the idea that **testosterone** itself may not be a major driver of developmental effects. Instead, **testosterone metabolites** may cause these effects. This type of research is important because it can tell us what may happen if normal hormone levels in early development are disturbed.

## Decoding the Language:

**Albumen:** The white part of the egg that is water-soluble and that contains proteins.

**Androstenedione:** A hormone and metabolite of testosterone.

**Clutch:** A group of eggs that are laid at one time.

**Column chromatography:** A method used to isolate a single chemical compound from a mixture of compounds. Each compound moves through the column at different rates and this allows them to be separated into fractions.

**Diffuse:** To permit or cause to spread freely. In the context of this study, we wanted testosterone that was placed inside the egg to diffuse into a growing embryo.

**Embryo:** An unborn or unhatched offspring that is actively growing. In the context of this research, the embryo is the developing starling inside the egg.

# Hormones and embryos: Understanding steroid metabolism in European starling eggs

Biological Sciences

**Embryonic development:** The process that takes place as an embryo grows and develops into an organism.

**Etiocholanolone:** A metabolite of testosterone.

**Hormones:** The signaling molecules that regulate the body and keep it in balance. These are produced by different glands within the body and are transported by the blood to target organs.

**Incubation:** The process of keeping an egg warm enough to develop until hatching.

**Metabolites:** The products of metabolism, or breakdown.

**Radiolabel:** A way to tag a substance or compound with a radioactive tag.

**Scintillation counter:** A machine that detects and measures the amount of radioactivity in a sample. It uses light pulses created by excited electrons or ions.

**Solid phase extraction:** A technique where compounds are suspended in a liquid mixture and are separated from other compounds in the mixture based on their physical and chemical properties.

**Testosterone:** A hormone that is important in the development of male secondary sex characteristics, but is also important in other body processes of both males and females.

**Yolk:** The yellow-orange, nutrient-rich portion of the egg that supplies food to the developing embryo.

**Learn More:** Below are some research papers for further reading.

C. Carere, J. Balthazart, Sexual versus individual differentiation: the controversial role of avian maternal hormones. *Trends Endo. Metab*., 18.2: 73–80 (2007).

N. Kumar, A. van Dam, H. Permentier, M. van Faassen, I. Kema, M. Gahr, T. G.G. Groothuis, Avian yolk androgens are metabolized instead of taken up by the embryo during the first days of incubation. *J. Exper. Biol*. 222.7 (2019).

R.T. Paitz, R.M.Bowden, J.M. Casto, Embryonic modulation of maternal Steroids in European starlings (*Sturnus vulgaris*). *Proc. R. Soc. B Biol. Sci*. 278.1702: 99–106 (2011).

*Synopsis edited by: Kate Evans, PhD (Anticipated Spring 2025) and Rosario Marroquin-Flores, PhD (Anticipated Spring 2022), School of Biological Sciences*.

# Turning up the heat: how turtle hatchlings respond to environmental temperature

**Featured Scientist:** Amanda Wilson Carter, PhD 2017, National Science Foundation Postdoctoral Research Fellow at the University of Tennessee (former PhD Candidate at Illinois State University, School of Biological Sciences)

**Birthplace:** New York City, NY

**My Research:** I study how animals are affected by changes in their environment.

**Research Goals:** I want to understand how changes in temperature affect animal **physiology**. I would like to be able to better predict how **climate change** will affect all types of animals.

**Career Goals:** I am currently working towards increasing the participation of underrepresented groups in science. My goal is to become a biology professor and researcher.

**Hobbies:** Traveling, playing with my dogs, and renovating my 1940's bungalow.

**Favorite Thing About Science:** I love having the freedom to explore questions that I think are necessary and important. Throughout my schooling and career, I have also discovered a passion for mentoring students through independent projects in the lab. There is something very special about watching an undergraduate conduct their first study and transform into a confident and capable young investigator.

**Organism of Study:** I study many animals, but my PhD research focused on turtles, mainly the red-eared slider (***Trachemys scripta***). In my current position, I conduct research on dung beetles.

Red-eared slider turtle (***T. scripta***)

Image source: https://about.illinoisstate.edu/rmbowde/research/

**Field of Study:** Eco-**physiology** | **Climate Change** | Plasticity | Development | Parental Effects

**What is Eco-physiology?** I broadly consider myself an eco-physiologist. I study how the **physiology** and behavior of animals are affected by their environment (mainly temperature).

# Turning up the heat: how turtle hatchlings respond to environmental temperature

**Check Out My Original Paper:** "Short heatwaves during fluctuating incubation regimes produce females under temperature-dependent sex determination with implications for sex ratios in nature"

**Citation:** **A.W. Carter**, B.M. Sadd, T.D. Tuberville, R.T. Paitz, R.M. Bowden, Short heatwaves during fluctuating incubation regimes produce females under temperature-dependent sex determination with implications for sex ratios in nature. *Sci. Rep.* 8.3: 1-13 (2018).

*Synopsis written by: Elyse McCormick, M.S.(Anticipated Spring 2022), School of Biological Sciences*

**Research at a Glance:** Temperature is very important for many parts of biology. For baby turtles, it is essential. Many turtles become male or female based on **incubation** temperature. This process is called **temperature-dependent sex determination**, or **TSD**. Warmer **incubation** temperatures make females, while cooler **incubation** temperatures make males. Until now, **TSD** has been studied in lab settings where the **incubation** temperature is held constant. However, since temperature doesn't stay constant in nature, this is pretty unrealistic. Amanda wanted to see what happens to **sex ratios** when turtles experience real, changing temperatures. She hypothesized that changes in temperature are very important to determining sex in turtles that have **TSD**. She predicted that turtles are very sensitive to short exposures to temperatures above the "**pivotal temperature**", or the temperature that will produce a population-wide 50:50 **sex ratio**. She also predicted that ovaries will start to grow within a few days of exposure to these warmer temperatures.

Amanda raised eggs using temperatures that went up and down with daily daytime and nighttime temperatures to mimic what a turtle would feel in nature. She then introduced eggs to short exposures of temperatures above the **pivotal temperature** to mimic heat waves. She was able to show that **sex ratios** can be changed by exposure to very short increases in temperature. Amanda used an Illinois population of the red-eared slider turtle, ***T. scripta***, for her research. Under the conditions in this study, ***T. scripta*** only needed approximately 8 days of exposure to warmer temperatures to produce a 50:50 **sex ratio**. At 5 days under the same conditions, 16% of the turtle **embryos** became female. This shows that even short exposures to warm temperatures can make an **embryo** become female. Amanda's research shows that using natural temperatures can lead to a more accurate prediction of turtle **sex ratios**

# Turning up the heat: how turtle hatchlings respond to environmental temperature

in nature. Her research also sheds light on another mystery. In Illinois, average temperatures are often so low that female turtles would be unlikely to be born. But somehow, females are still found in the population. Her research shows how female turtles end up in the Illinois population: turtle **embryos** only need a few days incubating under warmer temperatures to become female.

Amanda also wanted to see if **embryos** had the same response to temperature changes across the **nesting season**. She looked at differences between early and late season **embryos** to see how long it took under warmer temperatures to make female turtles. Late season **embryos** required less time at warmer temperatures to produce a 50:50 **sex ratio** than early season **embryos**. Mother turtles increase a hormone called **estrogen** in the **yolks** of their eggs across the **nesting season**, which leads to more females later in the season. Thus, late season **clutches** probably have a 'head start' on other **embryos** because they have more female **hormones** in their **yolk**. As a result, eggs don't need as much time in warmer temperatures to make females. Amanda used the results from her experiments to then develop a mathematical model to better predict **sex ratios** using natural temperatures measured from the field. This model helps predict the number of male and female turtles based on real, field temperatures.

**Highlights:** We just learned that females can be made after just a few days at warmer, **female-producing temperatures**. This finding helps us understand how sex is determined under more natural, changing temperatures. This finding is important because we can now more accurately determine **sex ratios** in turtle populations using available temperature datasets, like those available through the **National Oceanic and Atmospheric Association (NOAA)**. We are currently experiencing changing global temperatures, where turtle **embryos** are more likely to experience warm **incubation** conditions. Being able to predict **sex ratios** in turtles is important for their conservation. We might be able to accurately identify turtle species or populations that are most at risk of 100% female populations, which would be unable to make more offspring. We can use that information to direct conservation efforts and resources.

**What My Science Looks Like:** **Figure 1** from this paper is a great example of how different field temperatures can be. **Figure 1** reports temperature (y-axis) over the course of the summer **nesting season** (x-axis) for Illinois turtles. The solid horizontal line shows the **pivotal temperature** (**Tpiv**). It shows that, on average, temperatures have not been warm enough to produce females in this population for 23 years.

# Turning up the heat: how turtle hatchlings respond to environmental temperature

But when you break it down by year, there are bursts temperature warm enough to make females (see 1993 and 2012). In nature, temperature is not constant. Instead, it fluctuates. Amanda had to find a way to test what happens to turtle **embryos** in their natural environment. She needed temperature data from her study area to show that natural temperatures fluctuate around the **Tpiv**.

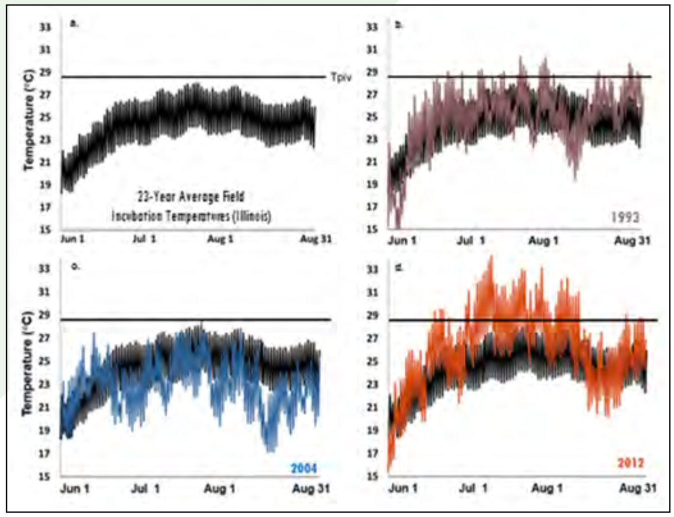



**Figure 1.** Average soil temperatures from Peoria, IL. *Figure adapted from Carter et al. 2018.*

**The Big Picture:** Amanda's research took a more realistic look at **TSD**. It allowed her to create a mathematical model to predict realistic **sex ratios** for hatchling turtles. These types of studies allow scientists to better understand what's happening in nature. Knowledge about how turtles live in the wild is important for more than just improving our understanding of turtle biology. They allow us to understand the wide-reaching effects of environmental impacts, such as **climate change**, on animals that are extremely sensitive to changes in temperature. **Climate change** could impact the **sex ratios** of hatchling turtles in ways we don't fully understand yet. But this study allows us to start to understand it. Amanda's model can be used to predict how **climate change** might affect future generations of turtles. It's possible that her model can help us understand how **climate change** will affect turtles, as well as the animals and plants that they interact with. If we can understand how **climate change** might impact a broad array of plants and animals, we may be able to help lessen its effect on our environment.

**Decoding the Language:**

**Climate change:** A change in global or regional climate patterns, often seen as major changes in temperature or precipitation.

**Clutch:** A group of eggs that are laid together at the same time by a single female.

**Embryo:** An unborn or unhatched offspring that is actively growing. In the context of Amanda's research, the embryo is the developing turtle inside the egg.

# Turning up the heat: how turtle hatchlings respond to environmental temperature

**Estrogen:** A steroid hormone that promotes the development and maintenance of female characteristics in the body.

**Female/Male-producing temperatures:** Female-producing temperatures are higher/warmer temperatures that cause red-eared slider turtles to become female. Male-producing temperatures are lower/colder and cause these turtles to become male.

**Incubation:** The process of keeping an egg warm enough to develop until hatching. In the context of Amanda's research, a male-producing incubation temperature is approximately 26°C and a female-producing temperature is approximately 31°C.

**National Oceanic and Atmospheric Association (NOAA):** A scientific agency within the United States Department of Commence that focuses on oceans, major waterways, and the atmosphere.

**Nesting season:** The duration of time that animals are actively laying eggs. In the context of Amanda's research, the nesting season lasts from late May to early July.

**Temperature-Dependent Sex Determination (TSD):** A form of sex determination where the incubation temperature determines whether the developing embryo will become male or female.

**Pivotal temperature (Tpiv):** The temperature that produces a population-wide 50:50 sex ratio.

**Physiology:** A branch of biology that studies how different parts of the body carry out chemical and physical functions.

**Sex ratios:** The amount of males compared to the amount of females, or vice versa.

***Trachemys scripta (T. scripta)*:** The scientific name for the red-eared slider turtle.

**Yolk:** The yellow-orange, nutrient-rich portion of the egg that supplies food to the developing embryo.

**Learn More:**

Illinois Turtles Fact Sheets (Illinois DNR): https://www.dnr.illinois.gov/publications/Documents/00000699.pdf

NASA's climate model site: https://climate.nasa.gov/

*Synopsis edited by: Rosario Marroquin-Flores, PhD (Anticipated Spring 2022), School of Biological Sciences*

# Evidence that offspring manage hormones produced by maternal stress

**Featured Scientist:** Amanda Wilson Carter, PhD 2017, National Science Foundation Postdoctoral Research Fellow at the University of Tennessee (former PhD Candidate at Illinois State University, School of Biological Sciences)

**Check Out My Original Paper:** "Evidence of embryonic regulation of maternally derived yolk corticosterone"

**Citation:** **A. W. Carter**, R.M. Bowden, R.T. Paitz, Evidence of embryonic regulation of maternally derived yolk corticosterone. *J. Exp. Biol.* 221.22 (2018).

*Synopsis written by: Ashley Waring, PhD (Anticipated Fall 2023), School of Biological Sciences*

**Research at a Glance:** When a mother is stressed, it can affect her future offspring. It can negatively affect them while they are developing and can also affect their survival after they are born. The goal of this study was to understand how **maternal stress** affects offspring by investigating how **corticosterone**, a hormone related to stress, affects **embryos**. In order to test this, turtle eggs from the species ***Trachemys scripta*** (red-eared slider turtle) were exposed to high levels of **corticosterone**. Amanda found out that the **embryo** will process most of the **corticosterone**. By the end of her study, less than 1% of the **corticosterone** was left in the **embryo**. This shows that, even when a lot of the stress hormone is present, it doesn't necessarily have a large effect on the **embryo**. However, if the amount of **corticosterone** was more than the **embryo** could handle, some of the **embryos** did not survive. When **embryos** did survive and hatch, the hatchling turtles tended to be smaller and have more physical **malformations** than those that were not exposed to **corticosterone**. **Embryos** that had been exposed to **corticosterone** also took longer to hatch. Amanda's results show that **maternal stress** causes a variety of effects on offspring and that too much **maternal stress** via increased **corticosterone** can have strong negative impacts. Some of these negative effects exist in traits that are important for survival and reproduction, so **maternal stress** can harm the offspring's chances at reproducing successfully. However, since the **embryos** were able to process some levels of **corticosterone**, it's possible that offspring can survive lower levels of **maternal stress**.

**Highlights:** **Figure 1** shows that, at high levels, **corticosterone** decreases how many turtle **embryos** will survive. The bar on the far left, labeled "Control", shows the mortality rate when no **corticosterone** is given to the **embryo**. Each bar to the right shows how many turtles died as the **corticosterone** dose increased. At low levels of

# Evidence that offspring manage hormones produced by maternal stress

**corticosterone** (0.05 µg and 0.15 µg) there is almost no change in survival. However, at a high level (0.5 µg), there is a large jump in **embryo** mortality. This suggests that there might be a threshold point, where the **embryo** can no longer cope with the amount of **corticosterone**.

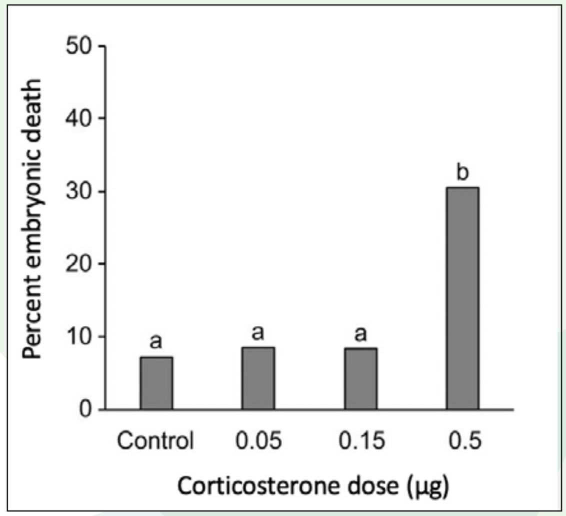



**Figure 1**. The percent of **embryos** that die after exposure to different doses of **corticosterone**. The x-axis shows the amount of **corticosterone** given to the **embryo** and the y-axis shows the percent of **embryos** that died. *Adapted from Carter et al. 2018.*

**What My Science Looks Like:** Below is a picture of Amanda collecting turtle eggs in the field. She looks for female turtles nesting in the dirt, then digs up the eggs that they lay.

*Pictured to the left is Amanda doing field work and collecting data during her graduate career at Illinois State University. Picture courtesy of Amanda's website:* https://amandawilson1213.wixsite.com/amandawilsoncarter

**The Big Picture:** This research provided the scientific community with a better understanding of maternal-offspring relationships. It helped explain the dynamics of stress and how **maternal stress** may affect the offspring. There are many ways that humans can cause stress in animal mothers, and the potential effects of that are still unknown. However, we now know that there may be a point where the level of stress causes harm. So, moving forward as a society, we need to be aware of how we treat our environment and what stressful effects that will have on animals.

**Decoding the Language:**

**Corticosterone:** The hormone produced in response to stress.

**Embryo:** An unborn or unhatched offspring that is actively growing. In the context of Amanda's research, the embryo is the developing turtle inside the egg.

# Evidence that offspring manage hormones produced by maternal stress

**Malformations:** Malformation refers to a part of a body that has not formed normally.

**Maternal Stress:** Maternal stress refers to the stress that a mother experiences during pregnancy.

**Physiology:** A branch of biology that studies how different parts of the body carry out chemical and physical functions.

***Trachemys scripta (T. scripta)*:** The scientific name for the red-eared slider turtle.

**Learn More:**

Sheldon Lab website (current Postdoctoral Fellow): https://eeb.utk.edu/people/amanda-carter/

Bowden Lab website (former Doctoral Program): https://about.illinoisstate.edu/rmbowde/

*Synopsis edited by: Brie Oceguera Perez M.S. (Anticipated Fall 2020) and Eric Walsh, M.S. (Anticipated Spring 2020), School of Biological Sciences*

# One way to better predict sex ratios in species with temperature-dependent sex determination

**Featured Scientist:** Amanda Wilson Carter, PhD 2017, National Science Foundation Postdoctoral Research Fellow at the University of Tennessee (former PhD Candidate at Illinois State University, School of Biological Sciences)

**Check Out My Original Paper:** "The Devil is in the Details: Identifying Aspects of Temperature Variation that Underlie Sex Determination in Species with TSD"

**Citation:** **A. W. Carter**, R.T. Paitz,R. M Bowden, The Devil is in the Details: Identifying Aspects of Temperature Variation that Underlie Sex Determination in Species with TSD. *Int Comp Biol.* 59.4: 1081-1088 (2019).

*Synopsis written by: Josselyn Gonzalez, M.S. (Anticipated Spring 2021), School of Biological Sciences*

**Research at a Glance:** The goal of this research was to help understand how animals respond to changes in temperature. To do this, Amanda used the red-eared slider turtle to study **temperature-dependent sex determination** (**TSD**). **TSD** is when the sex of an animal is affected by **incubation** temperatures. For example: red-eared slider turtles are typically male unless they experience warmer temperatures during development. If eggs are in warmer temperatures, even if it's just a few days, then it will cause the turtles to develop as female instead of male.

It is important to be able to predict **sex ratios**, or the amount of male and female turtles, in nature. We want to know how future changes in temperature may affect animals, especially for those that are sensitive to temperature. **Constant Temperature Equivalents** (**CTEs**) are used to guess the number of female turtles produced when eggs are exposed to temperatures that go up and down, similar to how temperatures go up during the day and down during the night. They are very common in this type of research and have been used to predict **sex ratios** for many years. Recent research suggests that **CTEs** may not be the most accurate way to predict **sex ratios** in the wild. Amanda's goal was to determine if using the number of days at higher temperatures (**female-producing temperatures**) is a better way to predict the **sex ratios** than using **CTEs**. To test her question, Amanda used two groups of red-eared slider turtles (one from Illinois and one from Louisiana). She also looked to see if the turtles from Illinois and Louisiana responded similarly to temperature changes.

Amanda found that the best way to predict turtle **sex ratios** is to count the number of days that eggs are at higher temperatures. Using the **CTE** that eggs experience

# One way to better predict sex ratios in species with temperature-dependent sex determination

throughout **incubation** was not as accurate. She also found that turtles from Louisiana were more sensitive to temperature changes than turtles from Illinois.

**Highlights:** Amanda collected 183 turtle eggs and put them into different temperatures as they developed. Amanda chose temperatures that go up and down, similar to how temperatures go up during the day and down during the night. All of the eggs started at **male-producing temperatures** (25 ± 3°C) for 25 days. She used 22°C (71.6°F) for her nighttime temperature and 28°C (82.4°F) for her daytime temperature. Then, she switched all of her eggs to **female-producing temperatures** (29.5 ± 3°C). She used 26.5°C (79.7°F) for her nighttime temperature and 32.5°C (90.5°F) for her daytime temperature. The eggs stayed at **female-producing temperatures** for 8, 11, 14, 17, 20, 23, 26, 29, 32, or 35 days. Finally, all eggs were returned to **male-producing temperatures** (25 ± 3°C) until they hatched. Once turtles were 6 weeks old, Amanda determined the sex of each hatchling. The sex of each hatchling from this experiment was combined with the previous year's data to help determine the best way to predict **sex ratios**.

**What My Science Looks Like:** In **Figure 1**, Amanda graphed the number of days that turtle eggs were at **female-producing temperatures** (x-axis) and the percent of turtle eggs that became female (y-axis). For the experiment described in this paper, the **male-producing temperatures** used was 25 ± 3°C (dashed line). A similar experiment was done the year before but the **male-producing temperature** was 27 ± 3°C (solid lines). Both **male-producing temperatures** (dashed and solid lines) follow the same shape on this graph. Because of this, Amanda concluded that the number of days at **female-producing temperatures** is an accurate way to predict the number of female turtles produced.

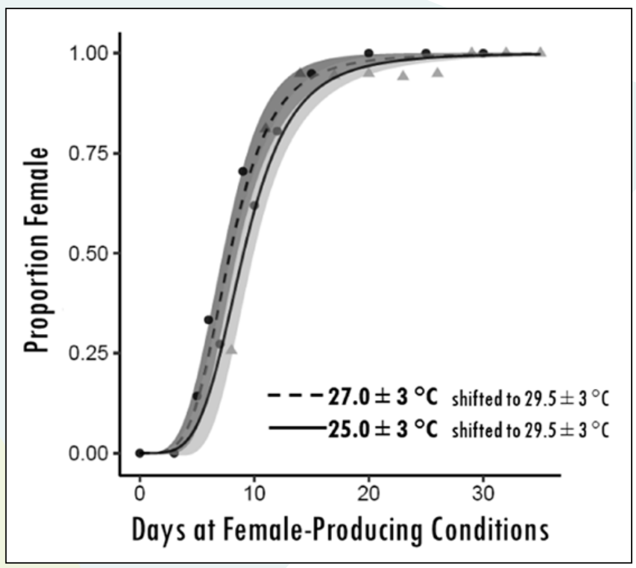



**Figure 1**. The proportion of female turtles produced when eggs are exposed to 0-35 days of **female-producing temperatures**. *Figure adapted from Carter et al. 2019.*

In **Figure 2**, Amanda also graphed the **CTE** (x-axis) and the percent of turtle eggs that

# One way to better predict sex ratios in species with temperature-dependent sex determination

became females (y-axis). In her first figure, Amanda was able to show that both **male-producing temperatures** (dashed and solid lines) resulted in the same **sex ratios**. But in this figure, she shows that they have different **CTEs**. Even though they had different **CTEs**, they resulted in the same amount of females. This means that **CTEs** are not a good way to predict **sex ratios**.

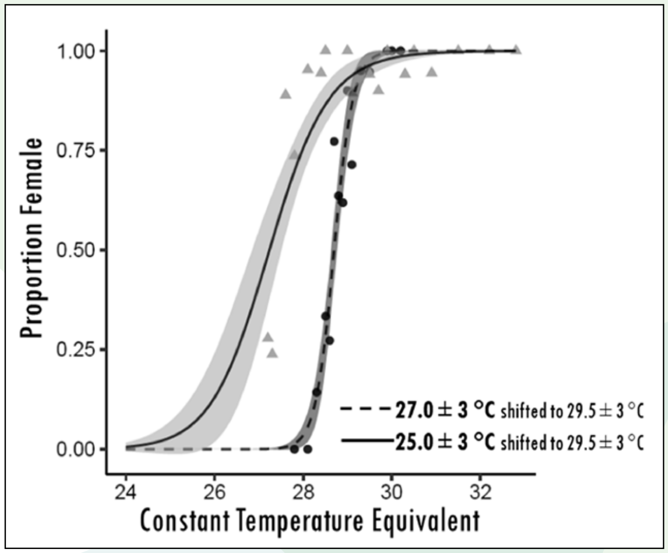



**Figure 2**. The predicted number of females produced using **CTEs**. *Figure adapted from Carter et al. 2019.*

**The Big Picture: Climate change** is a growing threat, and it is important to understand how animals will respond to these changes. Amanda studies the effect of temperature on animals with **TSD** to help us predict how species will respond to future climates. This research also helps with our conservation efforts. The more we know about how the environment will affect species, the better we can help to curb these effects.

**Decoding the Language:**

**Climate change:** A change in global or regional climate patterns, often seen as major changes in temperature or precipitation.

**Constant Temperature Equivalents (CTEs):** A tool used to guess the number of females produced when eggs are exposed to temperatures that go up and down, similar to how temperatures go up during the day and down during the night. CTEs are calculated using formulas based on what you use as the nighttime and daytime temperature. For example, Amanda used male-producing temperatures of 25 ± 3°C. Using the CTE calculation, she would expect to get the same number of females as if she incubated the eggs using a constant temperature of 25.98°C.

**Female/Male-producing temperatures:** Female-producing temperatures are higher/warmer temperatures that cause red-eared slider turtles to become female. Male-producing temperatures are lower/colder and cause these turtles to become male.

**Incubation:** The process of keeping an egg warm enough to develop until hatching. In the context of Amanda's research, a male-producing incubation temperature is approximately 26°C and a female-producing temperature is approximately 31°C.

**Physiology:** A branch of biology that studies how different parts of the body carry out chemical and physical functions.

**Sex ratio:** A ratio that compares the number of males to the number of females in a given population. For example, a 1:1 ratio means the number of males and females is the same and that 50% were male and 50% were female. The sex ratio is important because without enough males and females, the population may decline because there will be fewer opportunities to mate and produce offspring.

**Learn More:**

Temperature-dependent sex determination: https://www.scientificamerican.com/article/experts-temperature-sex-determination-reptiles/

*Synopsis edited by: Madison Rittinger, M.S. (Anticipated Fall 2021), School of Biological Sciences and Anthony Breitenbach, PhD (Anticipated Spring 2021), School of Biological Sciences*

# Effects of inbreeding in crickets

**Featured Scientist:** Kylie Hampton, M.S. 2020, School of Biological Sciences

**Birthplace:** Chicago, IL

**My Research:** I am interested in understanding how the female immune system is impacted by mating in decorated crickets.

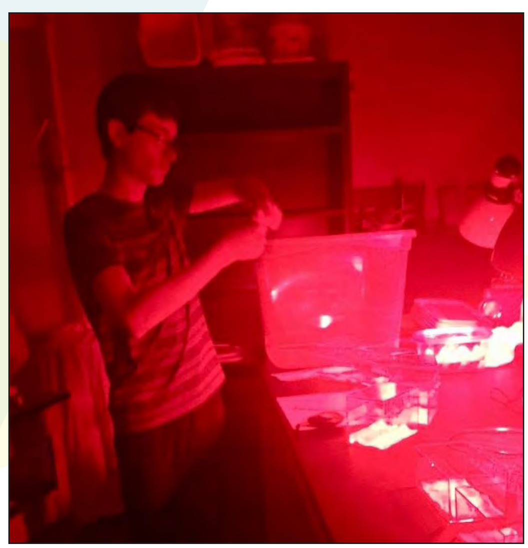
**Research Goals:** I hope to continue to work in the field of Behavioral Ecology because it provides the opportunity to ask really exciting research questions. I am specifically interested in mating behavior and the study of the insect immune system. However, I have diverse research interests and would be excited to gain experience in other fields as well!

**Career Goals:** I hope to be a research assistant in a lab that has similar research interests. I really enjoy doing lab work involving microscopy and microbiology but I'd be excited to give field work a try, too!

**Hobbies:** I love listening to true crime podcasts, drinking wine, reading, and painting!

**Favorite Thing About Science:** I love science because it's an entire field devoted to understanding the world. Every project that I have been a part of has been my personal attempt to contribute something new or to support existing knowledge, which I find to be a really rewarding experience.

**Featured Scientist:** Ian Rines, PhD (Anticipated Spring 2023), Biological Sciences



**Birthplace:** Charleston, SC

**My Research:** Male crickets produce **compounds** that they feed to females during mating. I study how male crickets use these **compounds** to manipulate female behaviors during and after reproduction.

**Research Goals:** I'm interested in the study of animal behavior and am broadly interested in continuing to work with insects. I would like to use

# Effects of inbreeding in crickets



**molecular techniques** to change how genes are expressed in crickets. These techniques should help me to understand what causes certain behaviors.

**Career Goals:** I'm not entirely sure what I'd like to do in the future, but right now, I'm hoping to do research in an academic setting.

**Hobbies:** I enjoy reading, watching movies, and (mild) hiking.

**Favorite Thing About Science:** My favorite thing about science is actually doing the science itself. It's fulfilling to design and carry out experiments to get at an answer to a question.

**Organism of Study:** We study the decorated cricket, ***Gryllodes sigillatus***.

**Field of Study:** Behavioral Ecology

***G. sigillatus**, or the decorated cricket. Pictured is a male (left) and a female (center). This pair has just finished mating and the female is bending around to remove the gift (the clear capsule she is grasping).*

**What is Behavioral Ecology?** Animal behavior is shaped over time based on ancestry and environmental surroundings. Good behaviors, those that help animals to survive, become more common. Bad behaviors, those that do not help animals survive, become less common. Behavioral ecology is the study of how these behaviors are formed.

**Check Out My Original Paper:** "Effects of inbreeding on life-history traits and sexual competency in decorated crickets"

**Citation:** S.K. Sakaluk, J. Oldzej, C.J. Hodges, C.L. Harper, **I.G. Rines**, **K. J. Hampton**, K.R. Duffield, J. Hunt, B.M. Sadd, Effects of inbreeding on life-history traits and sexual competency in decorated crickets. *Anim. Behav.* 155: 241-248 (2019).

**Research at a Glance:** This paper presents the results of two undergraduate research projects from several years ago. We helped to write the results of their work for publication. We studied how **inbreeding** affects mating and offspring production in decorated crickets. The crickets were originally collected in New Mexico in 2001. They were mated several times to siblings to create genetically distinct lineages of crickets. To see the impact of extreme **inbreeding**, we measured the number of offspring that the female crickets produced. Not surprisingly, we found that **inbred** crickets had fewer offspring. Here, **inbred** crickets were from the lineages that experienced **inbreeding**. These offspring

# Effects of inbreeding in crickets

took longer to hatch and grow into adults. We also did another experiment to see how **inbreeding** impacts **mating success**. From that study, we found that **inbred** males are less successful at completing their steps in mating, which involve attaching a **sperm package** to the female's genitalia. Surprisingly, we found that inbred females preferred **inbred** males from within their own line, that is, the males that were most closely related to them. This result seemed to contradict all the previous results found in the literature, which indicated that **inbreeding** had negative effects in these crickets. In general, **inbreeding** is considered a bad strategy for reproduction, as it can lead to **inbreeding** depression. **Inbreeding** depression is a reduction of **reproductive output** due to mating between relatives.

**Highlights:** Experiment 1: In the first experiment, we examined the effects of **inbreeding** on the offspring. We looked at hatching and development times, the number of offspring produced, the offspring size, and various other outcomes of mating. In **Figure 1**, we compared the number of days that it took to hatch for **inbred** and **outbred** crickets. Here, **outbred** crickets are from lineages that did not experience **inbreeding**. We found that **inbred** crickets take longer to hatch.

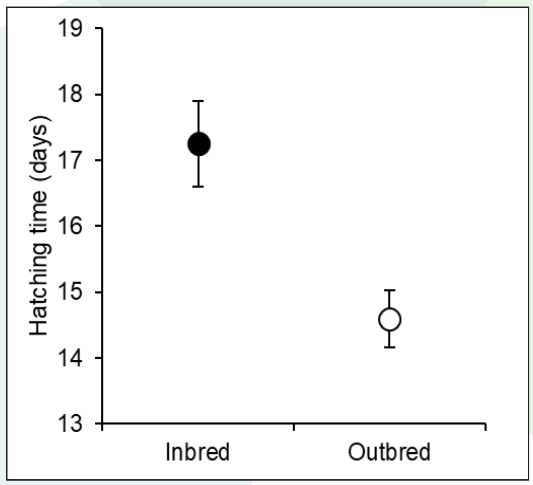



**Figure 1.** Hatching time of **inbred** and **outbred** offspring. The x-axis shows whether the crickets were **inbred** or **outbred**, while the y-axis is the average number of days that crickets took to hatch. Hatching time was the time from when the egg was laid to when the cricket emerged from the egg. *Figure adapted from Sakaluk et al. 2019.*

In **Figure 2,** we compared the number of offspring that were produced from **inbred** and **outbred** crickets. We found that **inbred** crickets have fewer offspring than **outbred** crickets.
In **Figure 3**, we looked at the amount of time that it took male and female offspring to develop into adults because sex is known to affect development time. We then compared development time for **inbred** and **outbred** crickets. We found that, regardless of sex, **inbred** crickets took longer to develop into adults. Overall, these results show that **inbreeding** can have negative impacts on the cricket offspring.

Experiment 2: Our second experiment, where we studied the effects of **inbreeding** on mating success, yielded very surprising results. We observed the behaviors of

# Effects of inbreeding in crickets

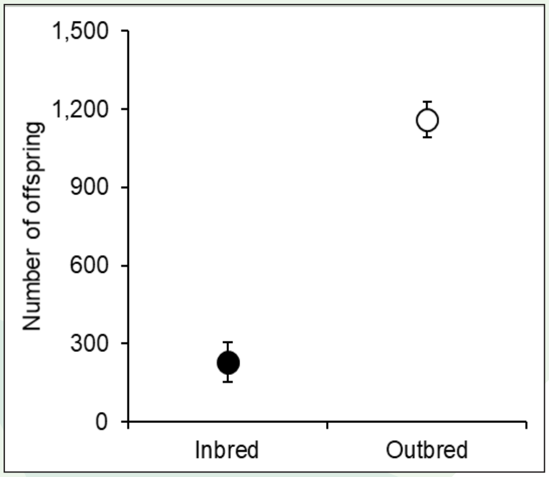



**Figure 2.** Number of offspring from **inbred** and **outbred** matings. Again, the x-axis shows whether the crickets were **inbred** or **outbred**. The y-axis is the average number of offspring produced by females. *Figure adapted from Sakaluk et al. 2019.*

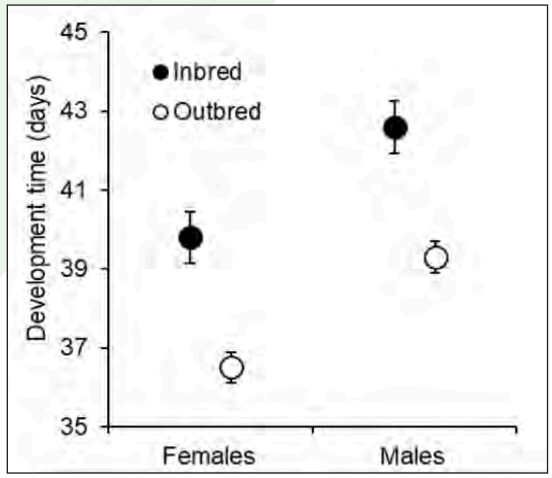



**Figure 3.** Development time of **inbred** and **outbred** offspring by sex. The x-axis shows the sex of the crickets, while the y-axis indicates the average development time in days. Development time was characterized by how long it took crickets to reach sexual maturity. *Figure adapted from Sakaluk et al. 2019.*

several cricket mating pairs. We paired **inbred** males with **inbred** females and **outbred** males with **outbred** females, then watched them mate. Next, we paired **inbred** males with **outbred** females and **outbred** males with **inbred** females. We did this to make sure that we had all possible mating combinations (**Table 1**). To observe mating, we placed males and females into small plastic containers in a dark, warm room. We had the room illuminated by red light because crickets can't see red light and it allowed us to observe them.

| **Mating Pairs** | |
|---|---|
| 1 | Inbred female x inbred male |
| 2 | Inbred female x outbred male |
| 3 | Outbred female x inbred male |
| 4 | Outbred female x outbred male |

**Table 1.** Layout of all mating combinations we observed.

To successfully mate, male crickets must attach the **sperm package** to the female. We found that **inbred** males had a lower chance of successfully attaching the **package**, regardless if they were paired with **inbred** or **outbred** females. We think that **inbred** males are just bad at mating. This is because previous research shows that males are more likely to experience the negative effects of **inbreeding** when it comes to the steps in mating.

Surprisingly, **inbred** females were more likely to mate with **inbred** males. Given these results, we cannot simply conclude that "**inbreeding** is bad", because **inbred** females seem to prefer mating with **inbred** males. While our experiments don't tell us why

# Effects of inbreeding in crickets

this is happening, we have several ideas. Our **inbred** lineages of crickets have been isolated within their **inbred** lines from a long time. It is possible that females don't recognize males from outside of their lineages. They may not see these outsider males as acceptable mates because they are only ever exposed to one type of male, that is, their **inbred** counterparts.

**What My Science Looks Like:** The image on the right is a mating chamber. We illuminate the room in red light, then observe the mating behavior through this observation chamber.

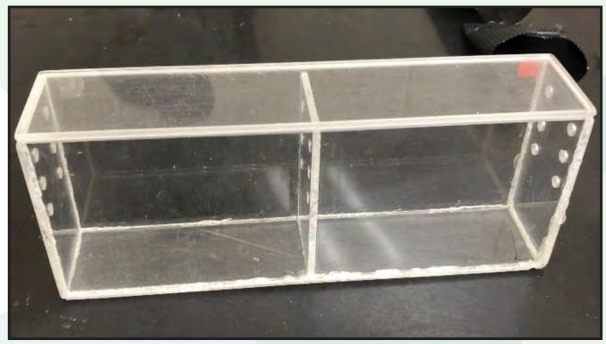


*Image of a mating observation chamber.*

**The Big Picture:** Studying the effects of **inbreeding** in crickets may not seem like an important thing to research. Our cricket species is not endangered or declining, but the same cannot be said for many other insect species. Substantial declines have been reported in bees, moths, butterflies, dragonflies, and other insects. There are approximately 1.5 million species on our planet, and insects account for more than half of those species. Compared to most vertebrates, it is much harder to determine whether an insect species is declining. When species go into decline, they are more likely to experience **inbreeding** and this can negatively impact the species. **Inbreeding** can harm offspring by shortening their lifespans, damaging their health, and reducing their **reproductive output**. Given these negative effects, we would expect **inbred** individuals to avoid mating each other. However, our research shows that animals may not always avoid **inbreeding**. This is particularly important because we also find that **inbred** males are less successful at mating. Our study has led to surprising results and further unanswered questions. Future research should help to unravel these mysteries, and focus on the effects of **inbreeding** on multiple traits (such as mating), not just **life history traits**.

**Decoding the Language:**

**Compound:** A chemical compound is made up of two or more elements. For example, table salt (NaCl) is a chemical compound because it is made up of both sodium (Na) and chlorine (Cl).

***Gryllodes sigillatus (G. sigillatus)*:** The scientific name for the decorated cricket.

**Inbreeding:** Reproduction between closely related animals.

# Effects of inbreeding in crickets

**Inbreeding depression:** The reduction of reproductive output due to mating between relatives.

**Life history traits:** Traits that may influence the fitness of an organism, specifically those involved in growth, survival, and reproduction.

**Mating success:** In the context of our study, mating success refers to the successfully completing all the steps in copulation, starting with a male courting and a female terminating sperm transfer.

**Molecular techniques:** A method used to manipulate and understand DNA, RNA, or protein.

**Outbred:** In the context of this study, these are crickets that were not subjected to full-sibling matings and were allowed to mix freely.

**Reproductive output:** The number of offspring produced by a female.

**Sperm package:** To mate, male decorated crickets will attach a sperm package to the genitalia of the female. The package contains a combination of proteins that the female will feed on after it is attached to her body. As she feeds, sperm from the package will enter the female's reproductive tract. The longer the package is attached to her body, the more likely it is for the female to be fertilized by the male's sperm. It is in the male's best interest to successfully attach the package and to make it as tasty as possible. This lengthens the amount of time that the female feeds and the amount of time that the sperm has access to her reproductive tract.

**Learn More:**

Insect decline: https://www.nationalgeographic.com/animals/2019/02/why-insect-populations-are-plummeting-and-why-it-matters/

*Synopsis edited by: Rosario Marroquin-Flores, PhD (Anticipated Spring 2022), School of Biological Sciences*

# Muscular activity makes Duchenne muscular dystrophy worse in a worm model

**Featured Scientist:** Kiley Hughes, PhD candidate (Anticipated Spring 2022), School of Biological Sciences

**Birthplace:** Seattle, WA

**My Research:** I study how **Duchenne muscular dystrophy** progresses. My research is focused on figuring out how the absence of the **dystrophin** protein causes the disease.

**Research Goals:** I want to continue using behavioral and **molecular techniques** to research **neuromuscular disorders**.

**Career Goals:** I want to be a scientist! I would love to work on a larger research team for a research institute that shares their work with the public.

**Hobbies:** I like to cook and paint, go outside when the weather allows it, and play with my two cats.

**Favorite Thing About Science:** My favorite thing about science is the unknown, there is always more to know and understand. I allow my curiosity to drive me.

**Organism of Study:** I study a species of microscopic worm, ***Caenorhabditis elegans***. ***C. elegans*** is a **model organism**, which means that scientists have been using it for research for many years and we know a lot about it. This species of worm is often used to study human diseases.

*The picture above is the nematode worm,* ***C. elegans****. They are about 1mm long, transparent, and feed on* ***microbes****!*

**Field of Study:** Molecular Neuroethology

**What is Molecular Neuroethology?** In this field, we use **molecular techniques** to understand the way organisms interact with the environment and specifically look at the cause of different types of behavior.

**Check Out My Original Paper:** "Physical exertion exacerbates decline in the musculature of an animal model of Duchenne muscular dystrophy"

# Muscular activity makes Duchenne muscular dystrophy worse in a worm model

**Citation:** **K.J. Hughes**, A. Rodriguez, K.M. Flatt, S. Ray, A. Schuler, B. Rodemoyer, V. Veerappan, K. Cuciarone, A. Kullman, C. Lim, N. Gutta, Physical exertion exacerbates decline in the musculature of an animal model of Duchenne muscular dystrophy. *PNAS.* 116.9: 3508-3517 (2019).

**Research at a Glance:** **Duchenne muscular dystrophy** is a **degenerative disease** that affects 1 in 3500 males and there is still a lot that we do not know about this disease. My research looks at how the loss of the muscle protein, **dystrophin**, leads to muscle death. I study the extent to which exercise might be able to protect **dystrophic** muscles. In this study, we used the nematode worm, ***C. elegans***, and our worms have **Duchenne muscular dystrophy**. We used them to show that calcium was not being properly regulated in their bodies, even before the worms show symptoms of the disease. We also observed that some types of muscle activity increased muscle repair. However, no treatment positively affected the life expectancy of **dystrophic** animals.

**Highlights:** For a muscle to contract, the body needs both energy and calcium. We used a special worm that has a green protein that will glow when it is in the presence of calcium. Worms move in a wave-like fashion. Because of this, each contracting muscle should have an opposite relaxed muscle. We used our special worm to do ***in vivo*** calcium measurements (**Figure 1**). We found that in **dystrophic** worms, not only was muscle calcium higher, but this persisted in both contracting and relaxing muscles.

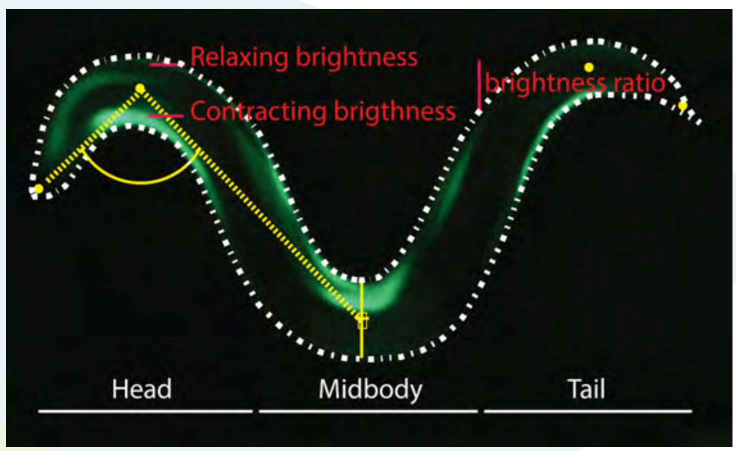



**Figure 1**. Image of the ***C. elegans*** **dystrophic** worm. The contracting muscle is bright and the relaxed muscle is dark. We used imaging software to measure the ratio of bright to dark muscles.

**What My Science Looks Like:** We can use **electron micrographs** to see what happens to the muscles in worms that have **Duchenne muscular dystrophy**. We make them by taking a worm and freezing it under very high pressure. The frozen worms are treated with heavy metals, then cut into really small slices (like pastrami). The slices shown in **Figure 2** are from the midbody of a worm and they show the worm's muscle structure. The image on the left is from a **wild type** worm, which means that this

# Muscular activity makes Duchenne muscular dystrophy worse in a worm model

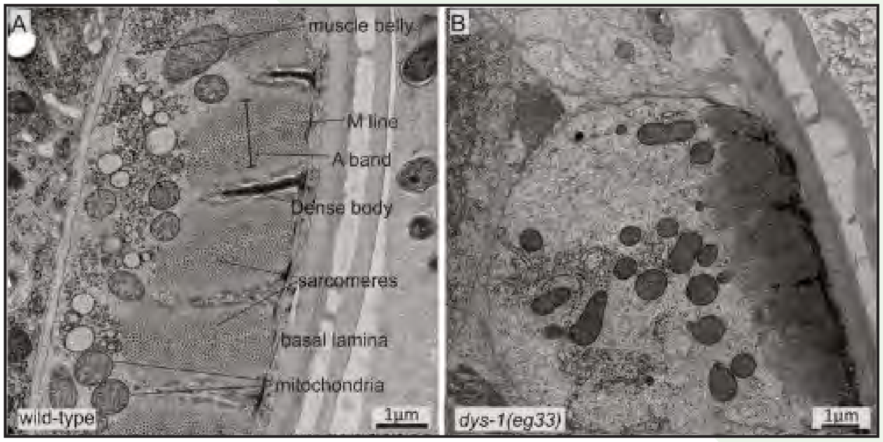



**Figure 2.** Magnified image of ***C. elegans*** muscle tissue in a **wild type** worm (left) and a **dystrophic** worm (right). *Adapted from Hughes et al. 2019.*

worm does not have the disease. The left image shows what a normal, healthy, muscle should look like. The image on the right shows the muscle structure of a **dystrophic** worm. The muscle in the **dystrophic** worm is degenerating.

**The Big Picture:** Thousands of people are living with **Duchenne muscular dystrophy** in the United States. These patients are wheelchair bound by the age of 12 and die prematurely from heart failure in their 30's. Research has been slow in this field because most of the animals that have the human version of **Duchenne muscular dystrophy** do not show the same type of degeneration. However, when our **dystrophic** worms burrow, they show muscle decline similar to humans. Using this model, we hope to understand how people with this disease are getting so sick.

**Decoding the Language:**

***Caenorhabditis elegans (C. elegans)*****:** The worms that we use to study Duchenne muscular dystrophy. This might seem strange, but they're a great model organism to understand the disease. What we find can be translated to humans!

**Degenerative disease:** Diseases that are caused by the abnormal break down of cells over time.

**Duchenne Muscular Dystrophy:** A fatal neuromuscular disorder that causes weakness in and loss of skeletal and heart muscle. This disease is caused by abnormal dystrophin proteins.

**Dystrophic:** A term used to refer to animals that have absent or abnormal dystrophin proteins.

**Dystrophin:** The muscle gene/protein that is absent in patients with Duchenne muscular dystrophy.

# Muscular activity makes Duchenne muscular dystrophy worse in a worm model



**Electron micrograph:** A form of imaging that can be done using a specialized microscope.

***In vivo*****:** Measurements or experimental procedures that take place inside of a living organism.

**Microbes:** A microscopic organism, like bacteria.

**Model organism:** A species that has been very widely studied. These species are often easy to breed and to take care of in the lab. Because they have been studied for so long, scientists have developed a lot of genetic resources that can be used to model human diseases using these animals.

**Neuromuscular disorders:** These are diseases that affect muscles and how the nervous system controls those muscles.

**Molecular techniques:** A method used to manipulate and understand DNA, RNA, or protein.

**Wild type:** An animal that has not been manipulated. It should have the same genetic and physical characteristics as if it were found in the wild.

**Learn More:**

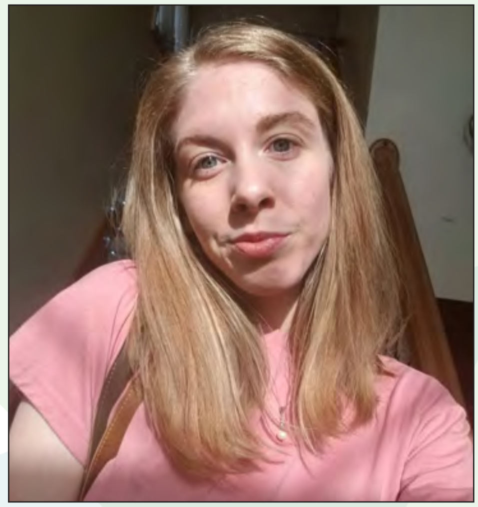
Why use the worm? https://www.yourgenome.org/facts/why-use-the-worm-in-research

*Synopsis edited by: Eric Walsh, M.S. (Anticipated Spring 2020) and Rosario Marroquin-Flores, PhD (Anticipated Spring 2022), School of Biological Sciences*

# Horoscope haters beware: a turtle's birthday may decide more than we think

**Featured Scientist:** Haley M. Nichols, B.S. 2017, School of Biological Sciences

**Birthplace:** Okinawa, Japan



**My Research:** I studied the role of **nesting season** and maternal investment on the behavior of juvenile freshwater turtles.

**Research Goals:** In the future, I would like to study how maternal nutrition or nesting conditions affect animal development and behavior.

**Career Goals:** I would like to work in managing invasive reptile species, particularly in sensitive areas such as the Florida wetlands.

**Hobbies:** I enjoy road trips with my fiancé and taking care of our cold-blooded pets and house plants!

**Favorite Thing About Science:** My favorite thing about science is learning new things to better understand the world we live in. I think it allows us to appreciate each moment a little more.

**Organism of Study:** I work with the red-eared slider turtle (***Trachemys scripta***).

*Image of **T. scripta** hatchling emerging from its shell.*

**Field of Study:** Animal Behavior & **Physiology**

**What is Animal Behavior & Physiology?** Animal behavior studies the way animals interact with themselves, others, and their environment. Their behavior can be affected by both internal and external conditions. Animal **physiology** studies the internal conditions like hormone regulation, temperature, or metabolic function. External conditions may be access to food and water or the presence of predators. Basically, we look at WHAT animals do and WHY they may be doing it.

**Check Out My Original Paper:** "Red-eared slider hatchlings (*Trachemys scripta*) show a seasonal shift in behavioral types"

**Citation:** **H. Nichols**, A.W. Carter, R.T. Paitz, R.M Bowden, Red-eared slider hatchlings (*Trachemys scripta*) show a seasonal shift in behavioral types. *J Exp. Zool. Part. A.* 331.9: 485-493 (2019).

# Horoscope haters beware: a turtle's birthday may decide more than we think

**Research at a Glance:** **Behavioral types** can be thought of as an animal's personality. They are patterns of behavior that repeat. The **behavioral type** that best supports survival may differ across environments, like seasons. We hypothesized that mothers could use their own behavior and **physiology** to help their hatchlings survive in the conditions that they are born in. That is, they can help them by making sure that the hatchling **behavioral type** matches the environment. To test this hypothesis, we measured **righting response** of juvenile red-eared slider turtles across the nesting season. The **righting response** is the ability of the turtle to turn itself over onto its abdomen (**plastron**) after it has been placed on its back (**carapace**). It is a signal for **behavioral type**, or "personality". We studied turtles hatching from early and late season **clutches** to understand if their personalities change based on **nesting season**. We found that the **nesting season** has a significant effect on **righting response**, with early season hatchlings **righting** more quickly than late season hatchlings.

To figure out why this happens, we explored two potential causes: maternal **estrogen** and **maternal investment**. From prior research, we know that eggs from late season **clutches** have more **estrogen** than eggs from early season **clutches**. To see if maternal **estrogen** was causing the difference in **righting response**, we coated early season eggs with an **estrogen hormone** to mimic the amount of **estrogen** found in late season eggs. We found that this did not affect hatchling behavior. To see if **maternal investment** was causing the difference in **righting response**, we looked to see if mothers were giving extra energy resources to her eggs when she lays them. We measured the mass of the egg, the hatchling mass, and the mass of the **residual yolk** on the hatchling's body. We found that early season eggs have more **yolk** than late season eggs. We also found that early season hatchlings were larger; they used a higher percentage of their **yolk** to grow new tissue, rather than just keeping existing tissues healthy. Interestingly, in both seasons, hatchlings that had less **yolk** also used a higher percentage of the **yolk** to make tissue, but we found no direct relationship to **righting response**. Overall, our research shows that **behavioral types** vary across the **nesting season**, but it appears that neither maternal **estrogen** nor **maternal investment** directly leads to this change.

**Highlights:** We we were able to show seasonal differences in the red-eared slider turtle (***T. scripta***) **righting response** between seasons, but were not able to determine its cause. We showed that early season turtles are given more **yolk** and use more of

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this **yolk** to grow tissues than late season turtles. We were able to determine the amount of **yolk** given to each hatchling by measuring the **yolk** from one egg of each clutch shortly after they were laid. After hatching, we measured the mass of each turtle and the mass of their remaining **yolk**. We then used statistical tests to look at the differences between these groups.

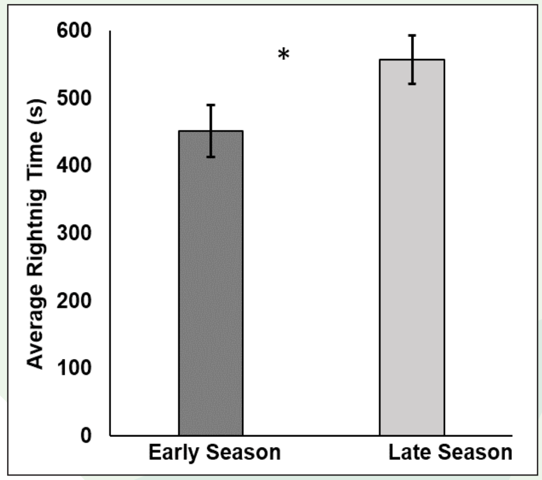


**Figure 1.** Hatchling **righting response** trial. The x-axis shows whether the turtle was laid in the early or late season. The y-axis shows the amount of time, in seconds, that it took for the hatchling to turn itself over. *Adapted from Nichols et al. 2019.*

**Figure 1** shows the results of our **righting response** behavioral test. It shows that turtles that came from eggs laid late in the **nesting season** righted themselves more slowly than those laid early in the **nesting season**.

**What My Science Looks Like:** The photo to the right shows the arena that we used during the **righting response** trial. The turtles in the top left corner cell and center cell have completed the desired behavior: they were able to turn from the **carapace** (back) to the **plastron** (abdomen). Each turtle is given a unique number based on their egg and **clutch**. We took photos of the **plastron** of each individual to verify the identity of the hatchling.

***T. scripta*** *in the trial arena.*

**The Big Picture:** My research is important because it helps us understand how a group of animal's behaviors and physical responses form. We used a species that is sensitive to the environment. Knowing how the environment shapes the body and behavior can help us predict how animals will respond to these changes.

**Decoding the Language:**

**Behavioral types:** A pattern of behavior in an animal.

**Carapace:** The top part of a turtle's shell.

**Clutch:** A group of eggs that are laid together at the same time by a single female.

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**Estrogen:** One of the primary female hormones; previous studies show it increases in eggs over the nesting season, causing more females in later clutches (Carter et. al 2017, see below).

**Maternal investment:** The services a mother provides her young, such as, provision of food, care, and protection.

**Nesting season:** The time of the year eggs are laid. For my species there is an early nesting season (late May to mid-June) and a late nesting season (mid-June to late June).

**Residual yolk:** The unused yolk remaining after turtle hatching.

**Righting response:** The behavior of turning oneself over from carapace to plastron (the "right" position for walking etc.).

**Plastron:** The bottom part of a turtle's shell.

**Physiology:** A branch of biology that studies how different parts of the body carry out chemical and physical functions.

***Trachemys scripta (T. scripta)*:** The scientific name for the red-eared slider turtle.

**Yolk:** The yellow-orange, nutrient-rich portion of the egg that supplies food to the developing embryo.

**Learn More:**

Physiology, Neuroscience, and Behavior sequence at ISU: https://illinoisstate.edu/academics/physiology-neuroscience-behavior/

Animal physiology: https://www.nature.com/subjects/animal-physiology

Animal behavior: https://www.nature.com/subjects/animal-behaviour

International Union or Conservation of Nature, *Trachemys scripta:* https://www.iucnredlist.org/species/22028/97429935

A.W. Carter, R.M. Bowden, R. T. Paitz, Seasonal shifts in sex ratios are mediated by maternal effects and fluctuating incubation temperatures. *Funct. Ecol*. 31: 876–884 (2017).

J.W. Gibbon, J.E. Lovich, On the slider turtle (Trachemy scripta). *Herpetol Monogr.* 4:1-29 (1990).

*Synopsis edited by: Rosario Marroquin-Flores, PhD (Anticipated Spring 2022), School of Biological Sciences*

# Infection outcomes not significantly affected by thermal variability in a bumble bee host-parasite system

**Featured Scientist:** Kerrigan B. Tobin, M.S. 2019, School of Biological Sciences

**Birthplace:** Normal, IL

**My Research:** I study how **climate change** influences bumble bee immune function and survival.

**Research Goals:** I want to continue to use a combination of laboratory and field techniques to address **native pollinator** conservation. I think it's important to understand how human impacts on Earth may have an effect on the organisms around us.

**Career Goals:** I'm currently a lab technician for the USDA, but eventually I'd like to be an Ecology professor, where I can teach and mentor students from various backgrounds about fascinating relationships in nature and how we can support biodiversity.

**Hobbies:** Crafts, especially throwing pottery and crocheting.

**Favorite Thing About Science:** It's so satisfying to find evidence and support for a theory!

**Organism of Study:** ***Bombus impatiens***, the common Eastern Bumble Bee

**Field of Study:** Ecology

**What is Ecology?** The study of how living organisms interact with each other and their surroundings. It's an interesting field because we can study ecology at different scales. We can look at how a  single organism interacts with its environemnt or study how complex networks of species interact in a community.

The Eastern Bumble Bee, ***B. impatiens***

**Check Out My Original Paper:** "Infection Outcomes are Robust to Thermal Variability in a Bumble Bee Host–Parasite System"

**Citation:** **K.B. Tobin**, A.C. Calhoun, M.F. Hallahan, A. Martinez, B.M. Sadd, Infection Outcomes are Robust to Thermal Variability in a Bumble Bee Host–Parasite System. *Integr. Comp. Biol.* 59.4: 1103-1113 (2019).

# Infection outcomes not significantly affected by thermal variability in a bumble bee host-parasite system

**Research at a Glance:** In this paper, we wanted to test whether changes in temperature make it more difficult for a bumble bee to fight off infections. **Climate change** is predicted to make temperatures more variable. These changes are likely to have an impact on many animals and how they interact with their environments. Living creatures have an optimum range of temperatures where their bodies perform the best. Outside of this range, their bodies cannot carry out important tasks. These ideas suggest that **climate change** might hurt animals because they will have to survive outside of the range of temperatures they are used to. Some scientists explain this using the "**beneficial acclimation hypothesis**" or **BAH**. This idea suggests that animals adjust to their environment, which gives them advantages for survival. For example, animals that live in the desert are particularly good at surviving in desert conditions. But, animals from the arctic are bad at surviving in the desert. On the same line of thought, we wanted to know if bumble bees were better at fighting off infections when they were living at the temperature that they were used to, their **acclimation temperature**. We wanted to see if bees living in a temperature outside their normal range were more likely to get parasites than bees kept at their normal temperature. To test this, we used the Common Eastern Bumble Bee as a host and a gut parasite that often infects bumble bees, ***Crithidia bombi***.

In our experiment, we used bees from four different colonies. Each bee was given one week to acclimate, or get used to, a specific temperature. They were acclimated to 21°C, to room temperature (between 25-26°C), or to 29°C. Next, we gave each bee one of two strains of the parasite, ***C. bombi***. This parasite is commonly found in the gut of the bumble bee. We gave the bees the parasite by mixing ***C. bombi*** into sugar water that was fed to them. After parasite exposure, bees were then put in a **performance temperature** of 21°C, room temperature (between 25-26°C), or 29°C. This means that some bees went back to the temperature that they were acclimated to, but others were placed into a different, **mismatched**, temperature. At four and six days after parasite exposure, we checked to see if the bees were infected by collecting their feces and looking for parasite cells inside. Eight days after parasite exposure, we froze the bees and measured how intense the infection was.

We found that the strain of ***C. bombi*** matters, because the two strains of parasites did not infect bees at the same rate. We also found that bees from different colonies had a different susceptibility to infection. This means that some bees are more likely to get an infection based on their colony of origin. Finally, we found that **constant**

# Infection outcomes not significantly affected by thermal variability in a bumble bee host-parasite system

and **mismatched** temperatures did not impact whether the bees became infected or how intense an infection became. These results mean that we did not find support for the **BAH**. Overall, our results suggest that small changes in temperature are not changing the relationship between bumble bee hosts and their parasites. We also showed that some parasites are better at infecting hosts than others, and some colonies are more likely to get infected than others. More work must be done to really understand how **climate change** might impact bee health, but our study is a good first step.

**Highlights:** The goal of this research was to test the **BAH** in the bumble bee host-parasite system. The **BAH** says that bees used to one condition, but given an infection with a parasite in different conditions, would have worse outcomes than bees that stayed in **constant** conditions. We tested this by keeping bees in **constant** temperatures or letting them get used to one temperature and then moving them to a new temperature. Then, bees that were kept at **constant** temperature and bees that experienced **mismatched** temperature were each given a dose of parasites. We screened the feces of each bee at 4 and 6 days after parasite exposure. We measured the intensity of the infection eight days after exposure to the parasite by performing **qPCR** on the gut of each bee. **qPCR** is a laboratory method that allows us to estimate the number of parasite cells contained in each bee.

We compared temperature treatments and infection over time to analyze our results. **Figure 1a** shows the number of bees that had parasite cells in their feces 4 days after they were infected. On day 4, there was no difference between bees that were kept at **constant** or **mismatched** temperatures. **Figure 1b** shows the number of bees that had parasite cells in their feces 6 days after they were infected. On day 6, more bees were infected, but there was still no difference between bees that were kept at **constant** temperature and those that experienced a **mismatched** temperature.

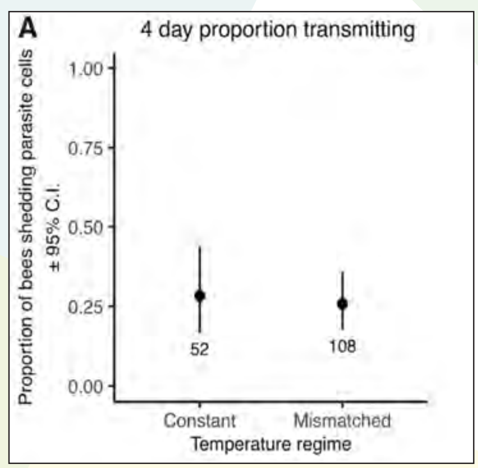



**Figure 1a**. Infected bees A) 4 or B) 6 days after ***C. bombi*** exposure. The x-axis shows the temperature treatment and the y-axis shows the proportion of bees that became infected. *Adapted from Tobin et al. 2019.*

**Figure 2** shows the intensity of the infection 8 days after the bees were infected. There was no difference between bees that were kept at a **constant** temperature and those that experienced a

**mismatched** temperature.

Taken together, **Figure 1-2** show that temperature did not change whether or not a bee was infected with the parasite or how intense the infection was. This means that we did not find support for the **BAH** in the bumble bee host-parasite system within the range of temperatures that we tested. More research needs to be done to understand the impact of **climate change** on this and other systems.

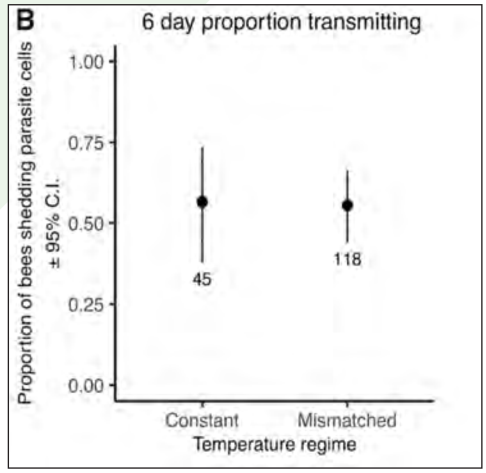



**Figure 1b**. Infected bees A) 4 or B) 6 days after ***C. bombi*** exposure. The x-axis shows the temperature treatment and the y-axis shows the proportion of bees that became infected. *Adapted from Tobin et al. 2019.*

**What My Science Looks Like:** The methods that I used in my experiment are presented in **Figure 3**. The boxes on the left show the temperature that a bee experienced during the 7-day **acclimation** period. After this, the bees were exposed to one of two strains of the ***C. bombi*** parasite. After exposure, bees were either returned to their original temperature (long dashed black arrows, **constant**), or they were assigned to a different temperature (short dashed gray arrows, **mismatched**). The boxes on the right side of **Figure 3** show the **performance temperature**. We quantified **transmission** 4 and 6 days after parasite exposure and we quantified the intensity of the ***C. bombi*** infection 8 days after parasite exposure.

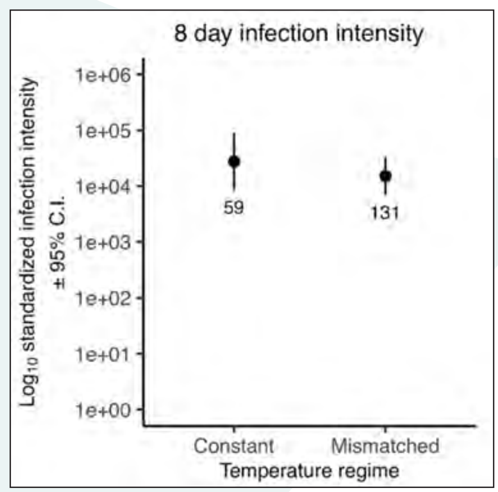



**Figure 2.** Intensity of ***C. bombi*** infection 8 days after bees were exposed to the parasite. The x-axis shows the temperature treatment and the y-axis shows a measurement of infection intensity. The data was **log-transformed** to make it easier to interpret. *Adapted from Tobin et al. 2019.*

**The Big Picture:** Human-driven **climate change** has many effects on earth, but its full range of impacts are not well understood. This research looked at how one part of **climate change**, thermal variability, will influence a specific host-parasite system. Although we didn't find support for the hypothesis that we tested, other effects of **climate change**, like prolonged exposure to high temperature or heavy rainfall, may impact bumble bees and other

# Infection outcomes not significantly affected by thermal variability in a bumble bee host-parasite system

pollinators. Humans need pollinators to help create the food that we consume, but we are not the only living things that rely on them. Many ecosystems need pollinator services to help plants thrive and produce the fruits that feed many other animals. Pollinator species are in decline and we cannot help them until we understand why it's happening. Research like mine is important because it helps us to see why pollinators are disappearing. Our work will help to focus conservation efforts.

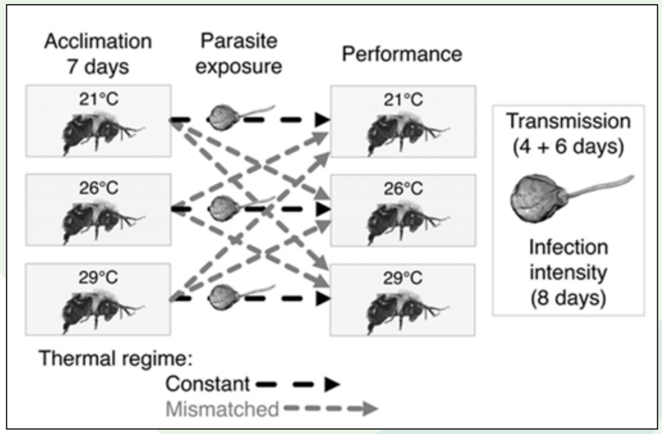



**Figure 3**. Breakdown of the methods used for the described experiments. Bees started in one temperature (left), were exposed to parasites (center), and were moved to a new temperature before being sampled (right). *Adapted from Tobin et al. 2019.*

## Decoding the Language:

**Acclimation temperature:** The temperature that an organism adjusts to over time. In the context of this experiment, this was the temperature that bees had 7 days to get used to before we introduced parasites and tested them.

**Beneficial acclimation hypothesis (BAH):** The BAH is a hypothesis that suggests that animals that have lived in a particular environment for a long period of time have adapted to that environment. These animals are particularly suited to this environment and will survive better than animals that are from somewhere else.

***Bombus impatiens (B. impatiens)*****:** The scientific name for the common Eastern Bumble Bee.

**Climate change:** A change in global or regional climate patterns, often seen as major changes in temperature or precipitation.

***Crithidia bombi* (*C. bombi*):** The scientific name for the gut parasite that was used to infect bees in this study.

**Constant:** The bees that started in one temperature and were shifted to the same temperature later in the experiment experienced a constant temperature.

**Log-transformed**: When data are in a format that is hard to analyze or show graphically, scientists can scale their data set by performing a mathematical operation, like an logarithm, to scale the data.

**Mismatched:** The bees that started in one temperature, but were shifted to another temperature later in the experiment experienced a mismatched temperature.

**Native pollinator:** “Pollinator” refers to any animal or insect that helps to carry pollen from flower to flower. A native pollinator is an animal that provides pollination services to flowers and is local to the area. For example, bumble bees are native pollinators because they naturally occur in the United States. The honey bee is not a native pollinator because these bees were imported into the country.

**Performance temperature:** In the context of this experiment, the performance temperature was the temperature that the bee was experiencing when we tested for the effects of the parasite infection.

**Quantitative polymerase chain reaction(qPCR)**: qPCR is a lab technique where known quantities (or standards) of DNA are amplified at the same time as unknown DNA samples. It is used to estimate the DNA concentration in each unknown sample based on how much the unknown samples were amplified relative to the standards.

**Transmission:** Transmission refers to whether or not the bee became infected with the parasite.

**Learn More:**

Pollinator Partnership: https://www.pollinator.org/

U.S. Department of Agriculture pollinator page, Logan, UT (This is where I work!): https://www.ars.usda.gov/pacific-west-area/logan-ut/pollinating-insect-biology-management-systematics-research/

Pollinator Conservation Resource Center: https://xerces.org/pollinator-resource-center

The Intergonvernmental Panl on Climate Change (IPCC): https://www.ipcc.ch/

*Synopsis edited by: Elyse McCormick, M.S. (Anticipated Spring 2022) and Rosario Marroquin-Flores, PhD (Anticipated Spring 2022), School of Biological Sciences*

# Making tiny gold particles to speed up chemical reactions

**Featured Scientist:** Pascal Nnaemeka Eyimegwu, M.S. 2019, Department of Chemistry

**Birthplace:** Nkalagu, Nigeria

**My Research:** I study how to make reactions go faster using **nanoparticles**.

**Research Goals:** I would like to continue to study **nanoparticles** (tiny materials) and how they might be used to speed up chemical reactions. This research would help scientists make medicine more efficiently.

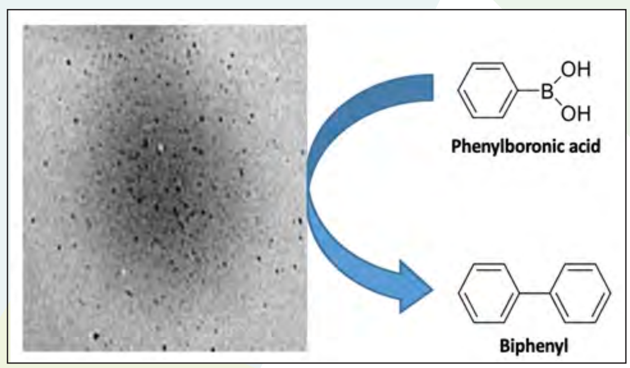
**Career Goals:** I want to be a Professor of Chemistry.

**Hobbies:** I like to travel and play soccer.

**Favorite Thing About Science:** Science is interesting because we can use it to interpret everything around us. It provides solutions to our problems. It's no wonder that we say "all in nature is chemistry".

**Organism of Study:** Gold **nanoparticles**

**Field of Study:** Analytical Chemistry




*Microscopic image of gold **nanoparticles** (left) and the chemical reaction that I used them for (right)*

**What is Analytical Chemistry?** Analytical Chemistry focuses on identifying and quantifying chemicals. For example, analytical chemists are responsible for making sure that your food and water are safe to eat and drink. Analytical Chemistry has been used to develop tools that can check if drivers are under the influence of alcohol, or to tell the difference between illegal drugs and medicines. In addition, this form of chemistry is used to check the quality of food and drugs to make sure that they are safe.

**Check Out My Original Paper:** "Atypical catalytic function of embedded gold nanoparticles by controlling structural features of polymer particle in alcohol-rich solvents"

# Making tiny gold particles to speed up chemical reactions

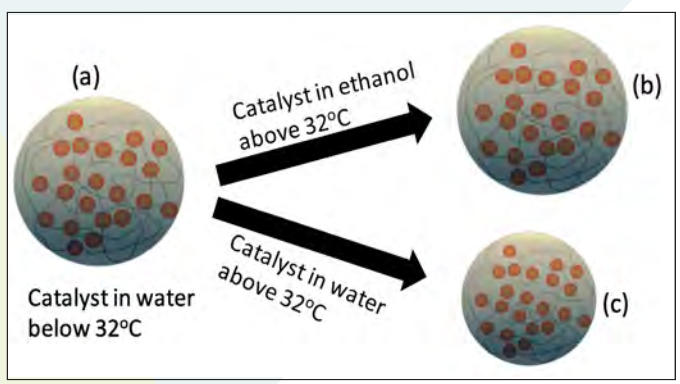


**Citation:** **P. N. Eyimegwu**, J.H. Kim, Atypical catalytic function of embedded gold nanoparticles by controlling structural features of polymer particle in alcohol-rich solvents. *J. Nanotechnol.* 30.28 (2019).

**Research at a Glance:** The goal of this study was to make stable **catalysts** that can speed up the chemical reactions used to make starting materials in pharmaceutical industries. A **catalyst** is a substance that makes a reaction go faster. The type of **catalyst** that I work with can be recycled multiple times without losing its efficiency, unlike the most common type, which can only be used once. In this research, gold **nanoparticles** are used as the **catalysts**. However, these **nanoparticles** attract each other and need to be stabilized to be used effectively. In my study, I stabilize gold **nanoparticles** using a specialized **polymer**, an **organic compound** used in making plastics. The **catalyst** that I made was highly stable, reactive, and produced no undesired by-products. The **catalysts** that I designed in my study can be used to produce important starting materials to **organic compounds** that are often used in pharmaceutical industries.

**Highlights:** The **catalyst** (gold **nanoparticles** in a **polymer**) that I made can be used to produce **biphenyl**, which is a useful starting material for making many **organic compounds**. I tried to use many different **solvents** to make **biphenyl**. The turning point of my research was in the decision to change the **solvent** for my **catalytic** reaction. The first **solvent** that I tried to use was water, but it resulted in poor yields of my target product, **biphenyl**. Ethanol was able to solve this problem.

Why was ethanol the trick? Unlike water, ethanol tends to remove the **organic compounds** that prevent the **catalyst** from performing well. Additionally, I used a **polymer** in my reaction. The **polymer** swells more when it is in ethanol than when it is in water, which guarantees more movement of **reactants** and **products** in and out of the **polymer**. The reaction with water creates a by-product, but when I used the ethanol, the by-product was no longer produced. Finally, I found out that




*The gold **nanoparticles** are used as the **catalyst**. The image on the left (a) shows the structure of the **catalyst** in water below 32°C. The images on the right show the **catalyst** in ethanol (b) and in water (c) above 32°C. As you can see, the **catalyst** in water looks smaller but remains swollen and slightly bigger in ethanol.*

# Making tiny gold particles to speed up chemical reactions

the yield is highest when I used ethanol (**Figure 1**). This is because ethanol can remove things from the **catalyst** that hinder the reaction.

Next, I wanted to make sure that my **catalyst** was stable. To do this, I needed to run a test to make sure that my **catalyst** was **recyclable**. Being **recyclable** means that the same **catalyst** can be used to speed up different batches of reactions without losing its strength. The first, second, and third cycle gave the same yield, but the yield went down on the fourth cycle and went down further on the fifth cycle. I was able to bring it up again after purifying it in water and putting it back into ethanol for the 6th cycle (**Figure 2**). As you can see in **Figure 2**, the **catalyst** produced just as much **biphenyl** after the 6th reaction as it did in the 1st reaction. This means that my **catalyst** should not be thrown away after one reaction because it will still be useful in another one.

**What My Science Looks Like:** On the following page, I show two images. The first one has two solutions. The one on the left (A) shows gold **nanoparticles** stabilized by a **polymer**, so that they don't clump together. The one on the right (B) shows the gold **nanoparticles** by themselves. These are the types of

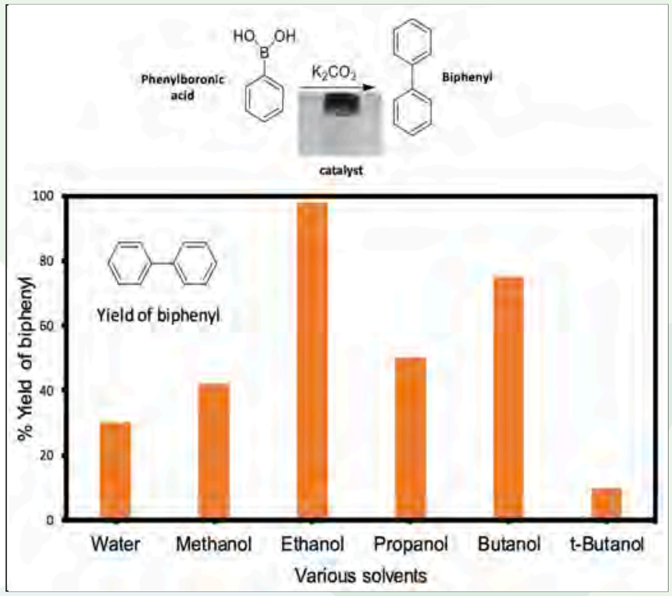



**Figure 1.** Production of **biphenyl** using **phenylboronic acid** as the starting material. The x-axis shows the **solvents** that I used in the **catalytic** reaction. The y-axis shows how much **biphenyl** was made. The orange bars represent the amount of **biphenyl** that was produced after a reaction in each individual **solvent**. *Adapted from Eyimegwu et al. 2019.*

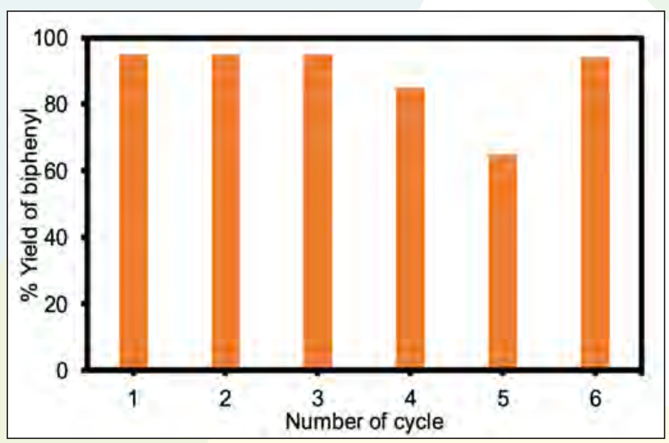


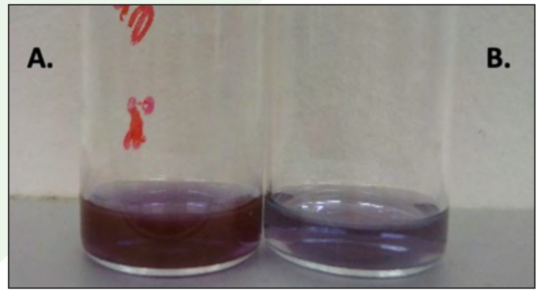

**Figure 2.** Testing **catalyst** stability. The x-axis shows how many times the same **catalyst** was used in different reactions. The **catalyst** was used for six different reactions. The y-axis shows how much product was made in each cycle. *Adapted from Eyimegwu et al. 2019.*

# Making tiny gold particles to speed up chemical reactions

Chemistry

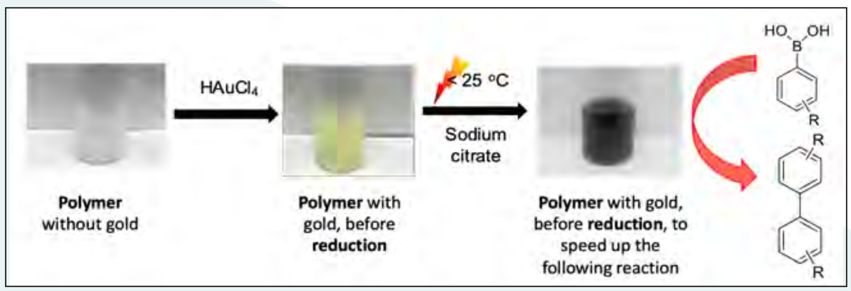
solutions that I work with in my research.

The second image shows the steps that I used to carry out the chemical reaction for my experiment. The goal was to make my target product, **biphenyl**.




*On the left (A), gold **nanoparticles** are inside of the **polymer**. On the right (B), the gold **nanoparticles** are by themselves. When they are by themselves, the **nanoparticles** are clear. This is because they are more unstable and there was no **polymer** to prevent other reactions.*

**The Big Picture:** Gold **nanoparticles** are safe and inexpensive. People are working hard to use them to make chemical reactions happen more quickly. My research introduces interesting properties of these **nanoparticles**: they change their **catalytic** activity when they are put in a **polymer** and are introduced to ethanol. The **products** of these reactions can be used to make medicines.




*These are the steps that are necessary to use gold **nanoparticles** to speed up chemical reactions. The first step is the mixing of the **polymer** and **gold solution**. The second step is the **reduction** of **gold solution** to gold particles. The third step is to use the gold particle to make **biphenyl**.*

## Decoding the Language:

**Biphenyl:** A useful starting material for making many organic compounds used by pharmaceutical companies.

**Catalyst:** Materials that make reactions go faster.

**Gold solution:** The first state of gold, before it is reduced to form particles.

**Nanoparticles:** Particles between the range of 1-100 nm in size.

**Organic compounds:** A chemical compound is made up of two or more elements. For example, table salt (NaCl) is a chemical compound because it is made up of both sodium (Na) and chlorine (Cl). An organic compound is any chemical compound that contains carbon. For example, sugar ($C_6H_{12}O_6$) is an organic compound. It is made up of carbon (C), hydrogen (H), and oxygen (O).

**Phenylboronic acid:** A chemical and the starting material that I used to make biphenyl.

# Making tiny gold particles to speed up chemical reactions

**Polymer:** An organic compound used in making plastics and nylon. In my research, I used it to stabilize gold nanoparticles so that the gold nanoparticles would not clump together.

**Reactants:** The materials that come together to produce another material.

**Recyclable catalyst:** A catalyst that can be used more than once.

**Reduction:** A way of making gold solution to become particle.

**Solvent:** A liquid that is used to carry out a reaction or to dissolve a solid material. Water is an example of a solvent.

**Products:** The result of a reaction, what we are trying to make.

**Learn More:**

Catalysis: https://en.wikipedia.org/wiki/Catalysis

Another research paper on catalysis: **P.N. Eyimegwu**, J.A. Lartey, J.H. Kim, Gold-Nanoparticle-Embedded Poly (N-isopropylacrylamide) Microparticles for Selective Quasi-Homogeneous Catalytic Homocoupling Reactions. *ACS Appl. Nano Mater.* 2.9: 6057-6066 (2019) .

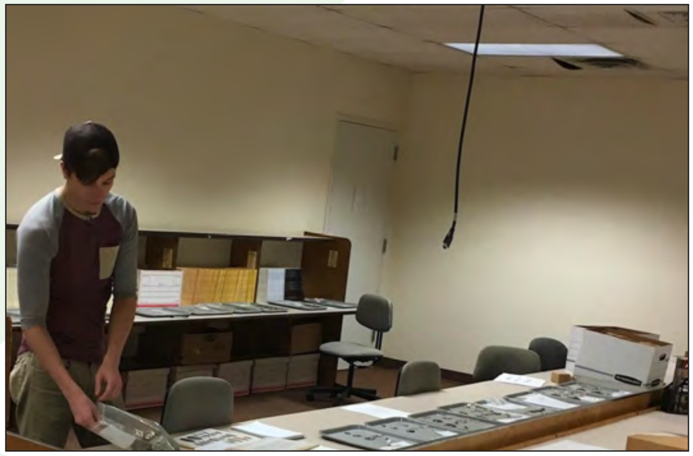
*Synopsis written by: Rosario Marroquin-Flores, PhD (Anticipated Spring 2022), School of Biological Sciences*

# Who were the people of Spracklen? Studying Native American community through their tools

**Featured Scientist:** Tyler R. E. Heneghan, M.S. 2018, Department of Sociology and Anthropology

**Birthplace:** Shelbyville, IN

**My Research:** I study tools made of stone to understand prehistoric Native American communities. The tools I study come from a place called Spracklen, an archaeological site located in Ohio.



*Tyler fills the Midwest Archaeological Lab with the Spracklen collection, sorting and separating the* ***lithics*** *by material type.*

**Research Goals:** I use a technique called **use-wear analysis** to better understand what the Ohio Hopewell peoples did in the uplands, and show archaeologists that more information can be gleaned from current collections, without the need to excavate more.

**Career Goals:** I am currently a student at Boston University School of Law studying international cultural heritage law. Cultural heritage law involves protecting, regulating, and repatriating cultural items, including the return of historic real property, ancient and historic materials, artwork, and intangible cultural heritage. The Native American Graves Protection and Repatriation Act is one federal legislation regulating museums' and federal agencies' collections.

I hope to aid in the return of cultural heritage around the world and bring it back to the people and communities to whom it belongs. This summer, I will intern with the environmental nonprofit law firm, Earthjustice: Tribal Partnerships. This law firm provides legal aid to Tribes, such as the Standing Rock Sioux, in their fight against the Dakota Access Pipeline. Upon graduation, I hope to use my legal degree, coupled with my M.S. in Anthropology from ISU, to continue in this field and better protect the past for the stakeholders of today and tomorrow.

**Hobbies:** Flintknapping (creating stone tools), vexillology (study of flags), scuba diving, and board games.

**Favorite Thing About Science:** I love the fluidity of science and how we will never run out of things to learn and improve upon.

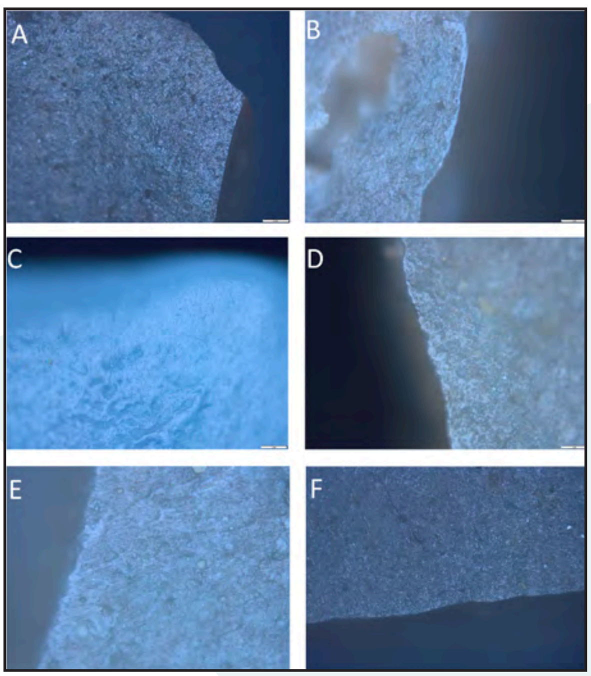
# Who were the people of Spracklen? Studying Native American community through their tools

**Organism of Study:** Stone tools

**Field of Study:** Prehistoric Archaeology

**What is Prehistoric Archaeology?** Prehistoric archaeology is the study of human culture through the analysis of the things that people leave behind. These may be structural items, plant, animal, **lithic**, or ceramic remains.

*Sample of **bladelets** recovered from Spracklen.*




*These are examples of **use-wear** traces from the stone remnants found at Spracklen. We look at the grooves of the stone to figure out what it was used for. Evidence of scraping can be found at the edge of the stone. Repeated scraping leads to **striations** that are perpendicular to the blade edge, but cutting leaves more generic **striations**. Evidence of use for softer materials (i.e. hide and meat) can be found further back on the stone. Evidence of harder contact materials can be found on the edge of the stone.*

*A) Meat cutting (magnified 50x)*

*B) Bone cutting/incising (magnified 200x)*

*C) Dry hide scraping (magnified 200x)*

*D) Dry hide cutting (magnified 200x)*

*E) Fresh hide scraping (magnified 200x)*

*F) General/Unknown (magnified 50x)*

**Check out my original paper:** "Spracklen (33GR1585): New Insights into Short-Term Middle Woodland Sites in the Uplands"

**Citation:** G.L. Miller, **T.R. Heneghan**, Spracklen (33GR1585): New Insights into Short-Term Middle Woodland Sites in the Uplands, *J. Ohio Archaeology.* 5: 1-15 (2018).

**Research at a Glance:** This paper is a summary of my recent fieldwork and analysis at Spracklen (33GR1585), a small upland site in Greene County, Southwest Ohio. Most of my analysis of prehistoric Ohio focuses on large Hopewell **earthworks**. **Earthworks**

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are man-made or otherwise artificial soil deposits that result from the humans that inhabit the area. Examples of these such **earthworks** are the Fort Ancient **Earthworks**, Mound City, and Seip **Earthworks**. The regions that surround these **earthworks** are called uplands and they remain understudied. Because of this, the whole picture of Hopewell peoples is incomplete.

At my field site, Spraklen, we found artifacts and structural features that showed us that the site was occupied for short periods of time, mainly during the Middle Woodland Hopewell period (100 BCE to 500 CE). During this time, the Hopewell peoples used stones to create tools. **Bladeletes** are the sharpened tools they used for cutting. **Bladelet cores** are the stones that were used to create these tools. As the **bladelets** are carved from their **cores**, small pieces remain. These are referred to as **chert debitage**. Spracklen contains dozens of **bladelets**, **bladelet cores**, and **non-local chert debitage**, consistent with other Middle Woodland Hopewell sites.

**Highlights:** The major portion of my master's thesis focuses on the **use-wear** of the completed stone tools at Spracklen. However, my publication focuses on the stone remnants, or by-products, that were found at my archaeology site. This is called **lithic debitage**. My job was to find the source for all of the **lithic debitage** I gathered at the site by comparing it to remnants from other known locations. Upwards of seventy percent of the 3,679 **lithic debitage** pieces I found were from Indiana Hornstone (a.k.a. Harrison County). Indiana Hornstone and Spracklen are not neighboring sites, so these tools must have been carried from one site to the other. I am continuously fascinated by how tools can reconnect prehistoric trade networks and voyages.

Another contribution I made to the article involved identifying **lithic debitage**, or "**flake**," size and shape. Previous research had identified signs of initial tool making. However, my advisor Dr. Miller and I found what we believe are by-products of tool resharpening. At the Spracklen site, we found thin **flakes** that were short and/or narrow in size. We compared the median thickness to the median relative thickness of these **flakes** to classify them into one of four categories: unitensive core reduction, intensive core reduction, tool resharpening, and tool manufacture (**Figure 1**). Unintensive and intensive **bladelet core** reduction is the process of shaping **chert** into small pieces. Once those pieces are small enough for transportation, they are turned into finished tools by the tool manufacturing process.

The **flakes** found at Spracklen indicate that the tools were mostly resharpened at this

# Who were the people of Spracklen? Studying Native American community through their tools

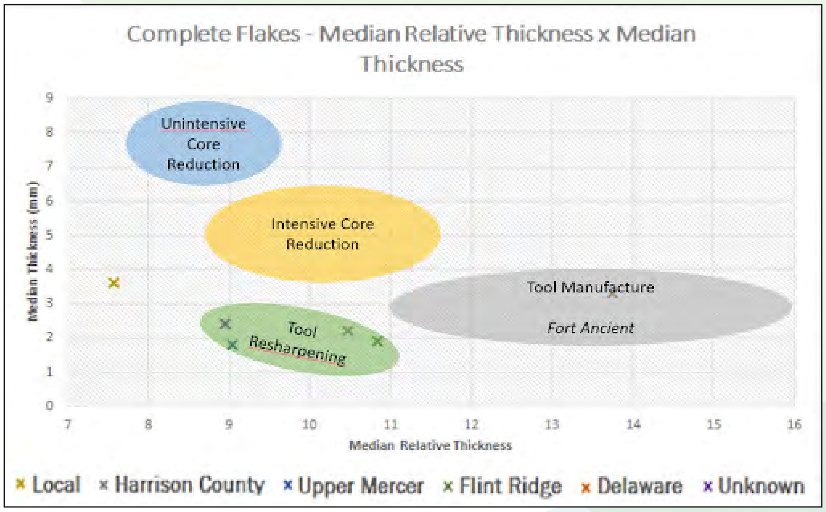
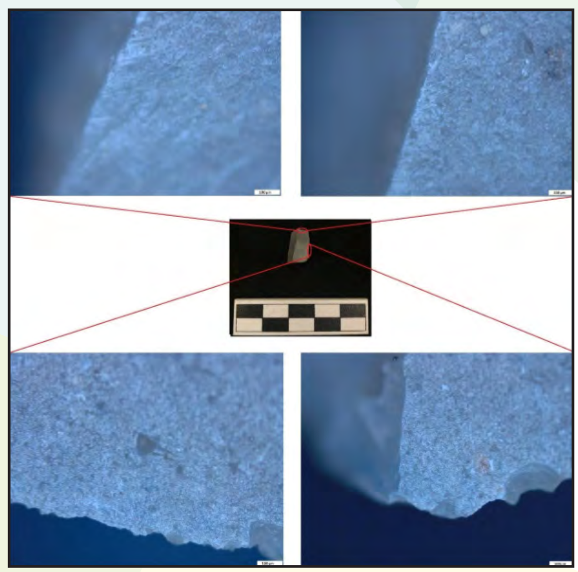



**Figure 1.** **Debitage** shape analysis from Spracklen. For each individual **flake**, I recorded median thickness and a relative median thickness. I plotted these two values against each other. The size of each individual **flake** is denoted by an X on the chart. Flakes of different sizes were grouped together based on their predicted use (colored ovals) and the color of the X signifies the original location of the **flake**. As you can see, the majority of the X's fall in the tool resharpening region, supporting the idea that Spracklen was a short-term settlement. This chart shows that tool resharpening was the primary process of stone reduction at Spracklen.

site. Spracklen was a short-term campsite and tools had to be durable for a successful trip to the uplands. Thus, tool resharpening allowed the Spracklen people to spend more time at the site before locating materials to make more tools. Since we found non-local stone remnants, or **cherts**, we can say that the general tool strategy for the Hopewell peoples was tool resharpening. This also supports that Spracklen was a short term site.

**What my Science looks like:** To the right are magnified images of **use-wear analysis** traces.

**The Big Picture:** Many archaeological sites consist of **lithic** and/or ceramic remnants. Without structural remains, these tools and ceramics are the best way to understand past life. I predominantly study the polish and **striations** on stone tools. I study this using



***Use-wear*** *traces indicating* ***lithic*** *use. The top two images show fresh hide scraping* ***use-wear*** *(100x). We can tell because of the perpendicular striations from the snapped bottom edge. The bottom two images show meat butchering* ***use-wear*** *traces (100x). We can tell by the polish developing further back from the blade edge. This polish pattern would develop as* ***bladelets*** *penetrate the meat.*

# Who were the people of Spracklen? Studying Native American community through their tools

a microscopic analysis called **use-wear analysis**. **Use-wear analysis** provides key insights into past life and allows for a better understanding of what people were doing at a point in time. Additionally, it is neither intrusive nor destructive to the tool.

**Decoding the Language:**

**Bladelets:** A stone tool used for many purposes and synonymous with the Ohio Hopewell peoples (think a prehistoric Swiss Army knife).

**Bladelet cores:** A stone used to create bladelets.

**Debitage/flakes:** The by-products of stone tool production.

**Earthworks:** Large man-made deposits of soil that indicate the presence of prehistoric human inhabitants.

**Lithics:** Stone remnants found at an archaeology site.

**Non-Local Chert:** Chert is a fine-grained sedimentary rock. This was a universally preferred material for making stone tools. In the context of this paper, non-local chert is chert that was transported to the site via trade or travel (i.e. chert originating from Indiana found in Southern Ohio).

**Striations:** Lines that indicate the direction that the tool was used. These are created by repeated motions from using the tool, such as cutting or scraping. This use creates diagnostic lines. For example, lines going perpendicular to the edge of the tool towards the center indicates scraping.

**Use-wear analysis:** The process of looking at stone tools under a microscope to analyze the polish and striations to understand how the tools were used.

**Learn More:**

Use-wear analysis: https://texasbeyondhistory.net/varga/images/use.html

Hopewell culture: http://www.ohiohistorycentral.org/w/Hopewell_Culture

Tyler's thesis: https://ir.library.illinoisstate.edu/etd/928/

*Synopsis edited by: Aleksandra Majewski, M.S. (Anticipated Summer 2020) and Rosario Marroquin-Flores, PhD (Anticipated Spring 2022) School of Biological Sciences*

# Religious/Cultural Identity Politics in "Secular" US and Europe

**Featured Scientist:** Nick Mullins, M.S. (Anticipated Spring 2020), Department of Politics and Government

**Birthplace:** Bloomington, IL

**My Research:** As a student of political science, I study politics. My focus has been on issues involving **globalization**, **identity politics**, nationalism, religion, democracy, global issues, and the international system of **nation-states**.

**Research Goals:** I would like to continue to study how the **nation-state** interacts with **globalization**. Some issues involve **identity politics**, which seem to be growing in importance. I am also curious about the role of religion and national identity in the future of the **nation-state**. Other research goals of mine cover global issues such as **climate change** and migration.

**Career Goals:** When I "grow up" I want to enjoy what I do and make a positive impact, but I'm still figuring out exactly how I'll do that. Some careers I have thought about include: a journalist in independent media covering politics and society, a researcher at a non-profit **thinktank**, or earning my PhD to become a professor and researcher.

**Hobbies:** I tend to get lost in discussions about politics or otherwise. I also love to travel, camp, hike, train my German shepherd dogs (x2), run, bike, and read nonfiction in my spare time.

**Favorite Thing About Science:** Science and social scientific studies help us learn about ourselves and the world we live in. I love it.

**Organism of Study:** Society, all the people within it, and institutions.

**Field of Study:** Political science, global politics and culture

**What is Political Science?** The field of political science falls under the category of social sciences. Social science involves lots of reading, observations, and analyses. It often begins with brainstorming an important question, crafting a plan to address the question, collecting data, and then interpreting the results. This research becomes part of a broader conversation in the scientific community and builds on our understanding of the world around us. The aim of political science is to understand or explain problems in politics and government. These problems can span from political ideas to institutions, from the behavior of individuals to groups, and much more. Political scientists will usually focus on a subfield, or a specific area of interest relating to politics and government.

My graduate program focuses on global politics and culture. In general, my work begins with **globalization**. **Globalization** refers to the expansion of global relationships. I am fascinated (and sometimes bothered) by modern politics of liberal democracies. My graduate work has led me to the question of **social cohesion**, or the extent of trust and cooperation in a society. I am also interested in how national identities can be "broken", or otherwise no longer collective, and other crises that face democracy.

**Check Out My Original Paper:** "Contesting the Secular West: Religio-cultural Identity Politics in Western Liberal Democracies"

**Citation:** **N.A. Mullins**, Contesting the Secular West: Religio-cultural Identity Politics in Western Liberal Democracies. *Zeitschrift für Religion, Gesellschaft und Politik* 3.1: 61-74 (2019).

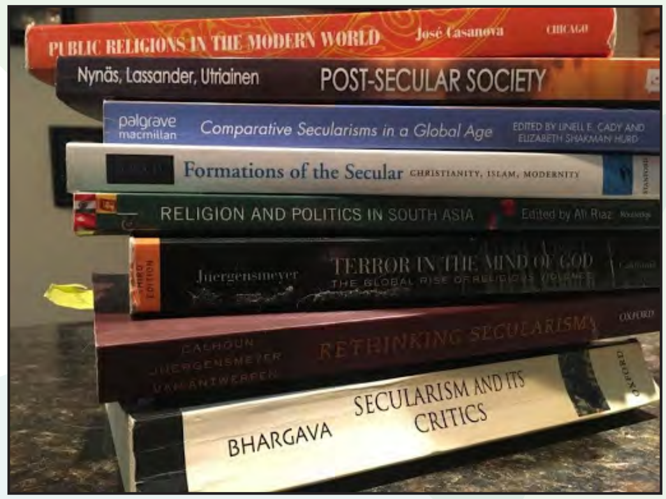
**Research at a Glance:** Political discussions often neglect the interaction of **secularism**, religious, and cultural identities in Western liberal democracies. But these important features must be considered in modern politics. For example, the United Kingdom's vote to leave the European Union (**Brexit**) and the election of Donald Trump as the President of the United States each took the world by surprise. In either event, liberal democracies are known for equal rights and non-discrimination. **Secularism** is the doctrine or policy that separates religion from public life and is common in liberal democracies. Yet religious influence is apparent in both national and world politics. It is often felt as **identity politics**, with a tendency for people or groups to form political alliances based on a shared identity. Increasing diversity in places like the United States and Europe has renewed debates over culture and national identity. Inclusion is now a matter of question. Societies are shaped by unique histories with **secularism**, religion and culture. These experiences may help to explain such modern trends. My paper explores this theoretical debate. Liberal democratic values are contested and I draw attention to the relationship between religion, politics, and national identity in the present era.

**Highlights:** I wrote the first version of this paper for a seminar in comparative politics on the topic of religion. I drew connections between the cultures of modern society and their historical experiences with religion and **secularism** and was inspired to write on this topic. For a long time, probably since I was a young teenager, I've been

# Religious/Cultural Identity Politics in "Secular" US and Europe

a huge nerd for nonfiction books on **secularism**. I took a graduate seminar with Dr. Ali Riaz here at ISU and it really helped to clarify my research interests. The course was essential to my research in the politics of religion and identity, and in the discovery of my research interests.

**What My Science Looks Like:** A stack of books, 25-30 tabs open on my laptop, mind maps, and hand-scribbled notes.




*Here are some of the books I referenced when writing my paper. What this picture doesn't capture is all the articles, reading, notes, and many hours of time put into it!*

**The Big Picture:** Identity and culture shape the norms, values, and worldviews of individuals and societies. These may be understood as "collective" values or identities around broad ideas, but identities and cultures in societies are often more fragmented. Religions can be supportive of tolerance and other democratic values. They can also take the opposite stance. **Secular** worldviews are similar to religion in that way by contradicting tolerance. In either case, religious, ethnic, or cultural minorities may face discrimination from the majority. For example, secularism in France can be restrictive against religious expression and cultural minorities. The reality is that we live in a diverse world. Identity and cultural issues that shape our societies deeply impact our politics. These norms and values are all subject to debate, and it seems to be increasingly so. Additionally, according to the Fragile State Index, **social cohesion** is worsening in the U.S. I have a hunch this fracturing has something to do with **identity politics**. The unique histories of societies shape these modern debates and therefore, present politics, which is a key point to remember.

**Decoding the Language:**

**Brexit:** This term describes the United Kingdom's vote to withdrawal from the European Union.

**Climate change:** A change in global or regional climate patterns, often seen as major changes in temperature or precipitation.

# Religious/Cultural Identity Politics in "Secular" US and Europe



**Globalization:** This concept has many dimensions. It is generally understood as the expansion of human relations across geographical space. This involves the global economy, politics, culture, environment, and ideology.

**Identity Politics:** Identity politics places emphasis on individuals and groups. For example, a politician may run for office as a Christian woman and use her identity as a Christian and/or as a woman to appeal to like-minded voters. On the political left, identity politics tends to focus on perceived (or actually) marginalized groups. On the right, it is often about protecting traditional views surrounding national identity, such as, beliefs about race, ethnicity, and/or religion.

**Nation-State:** The nation is the political community that legitimizes the state over its territory. Nation-states make up the international system. They are formed by people in a common territory, who may have shared history, traditions, or language. It is territory with a shared cultural and political boundary.

**Secularism:** This concept can be simply defined as the doctrine or policy of separation of church and state. It is a basic system of beliefs for how relations between the state and religion are conducted. For example, the political and religious authorities are generally kept separate in a secular state. It can also be understood as a belief system or way of life corresponding to the decline or absence of religious influence on everyday life.

**Social Cohesion:** One simple definition of social cohesion is the level of trust in a society, or the extent to which individuals in a society trust one another. It can also be understood as the degree of social stability, how connected we are, and the general wellbeing and representation of individuals and groups within society.

**Thinktank:** This is an organization with a mission to conduct research to share ideas and/or policy recommendations.

**Learn More:** Below are some useful resources relevant to this research and helpful to my current thesis project.

Fragile States Index: https://fragilestatesindex.org/country-data/

Identity politics (opinion): https://www.washingtonpost.com/news/theworldpost/wp/2018/09/18/identity-politics/?noredirect=on

Identity politics (opinion 2): https://www.nytimes.com/1995/12/18/opinion/abroad-at-home-an-atomized-america.html

# Religious/Cultural Identity Politics in "Secular" US and Europe

More on identity politics: https://psmag.com/social-justice/americans-are-staying-as-far-away-from-each-other-as-possible

Religious extremism: https://fpif.org/ayatollah-trump-the-global-rise-of-the-christian-right/?fbclid=IwAR1FKqlPjbhFtfpqlM17fV5bvAnaT7s5oABsDZInYmY6yZb7HLN8dfxGNdk

Political consensus (opinion): https://www.washingtonpost.com/news/theworldpost/wp/2018/09/21/social-cohesion/

The Great Regression: http://www.thegreatregression.eu/

Migration and inclusive societies: https://en.unesco.org/themes/fostering-rights-inclusion/migration

Here are some published papers and books on similar topics:

Identity politics: F. Fukuyama., Identity: The demand for dignity and the politics of resentment. Farrar, Straus and Giroux. New York. 2018.

Globalization: M.B. Steger,  Globalization: A Very Short Introduction. Oxford University Press. 2009

Social cohesion: X. Fonseca,S. Stephan, F. Brazier, Social Cohesion Revisited: A New Definition and how to Characterize It. Innovation. *Eur. J. Soc. Sci.* 32.2: 231-53 (2019).

*Synopsis edited by: Rosario Marroquin-Flores, PhD (Anticipated May 2020), School of Biological Sciences*

# Acknowledgments

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We would like to express our thanks to all those who have participated in the creation of this journal and to those who have been supportive along the way. We would like to extend a special thank you to **Jen Bethmann**, the ISU web accessibility coordinator in Administrative Technologies, for helping us to make the digital version of the *Research Spotlight* accessible to all people.

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