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Department of Biology and Earth Science

SENIOR RESEARCH SYMPOSIUM

April 13, 2016 • 8 a.m. – 4 p.m.

Roush Hall 114 and the Fisher Gallery



OTTERBEIN
UNIVERSITY

Department of Biology and Earth Science Senior Research Symposium

April 13, 2016

8:00 POSTER DISPLAY AND REFRESHMENTS - FISHER GALLERY

8:10 - 9:05 PODIUM PRESENTATIONS - ROUSH 114

8:00 **Opening Remarks, Dr. Halard Lescinsky**

8:05 **Mollie E. Kemp:** Cognition and Problem Solving Using Detour Reaching and Novel Object Tasks in the Budgerigar (*Melopsittacus undulatus*)

8:20 **Breanna C. Brown:** Characterization of a Putative Cell Signaling Gene in the Bacterial Plant Pathogen *Streptomyces scabies*

8:35 **Jillian J. Keefer:** Resurgence of *Acropora* Species Corals on Mid Shelf Patch Reefs, Southwater Caye Marine Reserve, Central Belize

8:50 **Brent B. Mullin:** The Impact of Human Activity on the Populations of Zebra Mussels in Alum Creek Reservoir

9:05 – 9:25 POSTER PRESENTATIONS (GROUP A), REFRESHMENTS – FISHER GALLERY

9:25 – 10:25 PODIUM PRESENTATIONS - ROUSH 114

9:25 **Megan K. Locke:** Effects of Percutaneous Closure of Patent Ductus Arteriosus in Infants Less than One Year of Age: A Systematic Review

9:40 **Scott M. Shipkowski:** Investigation of Shale Gas Drilling and Groundwater Quality, Tioga County, PA

9:55 **Renae J. Gerchow:** North American Wolves as a Model for Increasing Reintroduction Success of African Wild Dogs

10:10 **Trevor S. Smoot:** A Comparative Analysis of Fish and Mussels in Lower Big Walnut Creek

10:25 - 10:50 POSTER PRESENTATIONS (GROUP B), REFRESHMENTS – FISHER GALLERY

10:50 – 12:05 PODIUM PRESENTATIONS - ROUSH 114

10:50 **Matthew K. Vieth:** Effects of Browse and Behavior on Fecal Constitution of African Elephants in a Zoo Setting

11:05 **Cory R. Usher:** Growth Rate Plasticity in Larval Northern Leopard Frogs

11:20 **Connor E. Musial:** Temperature Fluctuations Present in Fractured Aquifer at Remediation Site in Taneytown, Maryland

- 11:35 **Meaghan L. Graver:** The Efficacy of Educational Signage in Zoos
Regarding the Palm Oil Industry
- 11:50 **Christopher D. Rapp:** Protein Binding to Cyclic di-GMP in
Streptomyces coelicolor
- 12:05-1:20 RECESS FOR LUNCH
- 1:20 -1:40 POSTER PRESENTATIONS (A & B) – FISHER GALLERY
- 1:40 – 2:40 PODIUM PRESENTATIONS – ROUSH 114
- 1:40 **Samantha L. Perry:** Effects of Enrichment on the Behavioral Activity
Budget of Hand-reared Coyotes (*Canis latrans*)
- 1:55 **Morgan A. Stark:** Determination of Cyclic-di-GMP- Controlled Gene
Expression in a pharmacologically Important Bacterium
- 2:10 **Rachel B. Dalton:** A Retrospective Analysis of Trends in Central
Ohio Wildlife Health Using Records from a Wildlife Rehabilitation
Facility
- 2:25 **Derek Randall:** Effects of Enrichment on the Display of Stereotypic
and Natural Behaviors of an Amur Tiger (*Panthera tigris altaica*)
- 2:40 - 2:55 Refreshments – Fisher Gallery
- 2:55 – 3:40 Podium Presentations - Roush 114
- 2:55 **Nicholas P. Wilburn:** The Effects of Immediate Land use on the
Distribution and Abundance of Aquatic Insect Larvae in the Lower
Big Walnut Creek
- 3:10 **Samantha L. Hargrove:** A Pre-human Baseline for Stressors
Limiting Staghorn Coral: Evidence from Sub-fossil Skeletons
Preserved in Earthquake Scarps, Central Belize
- 3:25 **Macie D. Smith:** Personality in Giant Panda (*Ailuropoda*
melanoleuca) Cubs across Different Environmental Contexts
- 3:40 CLOSING REMARKS, DR. HALARD LESCINSKY, GROUP PHOTOGRAPH
- 4:30-7:00 SENIORS, FACULTY AND STAFF CELEBRATION
Old Bag of Nails, 24 N. State St., Westerville, OH 43081
- 4:30 Gathering Time
- 5:30 Dinner and Awards

POSTERS GROUP A

- Claudia E. Buckle:** Why was Ebola not contained quickly?
- Kelsey L. Burkitt:** A Review of Variables Affecting Behavior Differences in Chimpanzees (*Pan troglodytes*) and Bonobos (*Pan paniscus*)
- Kailey A. Giancola:** Anatomical Changes of Cortical Neurons in Rodents with the Presence of Norfetamine
- Alicia M. Lindberg:** A Review of the Secondary Metabolites Fumonisin and Aflatoxin in Food Products
- David B. Monaco:** Topography Changes and Their Effects on Tornadogenesis in Ohio
- Rebecca A. North:** Dugong Decline in the Great Barrier Reef
- Myriah P. Repuyan:** Identification and Characterization of *Streptomyces* Transposon Mutants
- Jr. Seminar students:** Effects of Age, Sex, Weight, and Hand Dominance on Hand Grip Strength

POSTERS GROUP B

- Caitlin D. Boyd:** Equine Protozoal Myelencephalitis (EPM): Diagnosis, Epidemiology and Treatment of a Debilitating Equine Disease
- Kimberly J. Corr:** Effects of Olfactory Stimulation and Environmental Enrichment in Captive Housed Felids
- Charles O. Grayson:** Fibromyalgia and Rheumatoid Arthritis: Does Weather Affect the Level of Pain Reported by Patients with These Conditions?
- Sarah R. Holbrook:** Ebola: A Tale of Two Epidemics and Lessons Learned
- Catilyn E. Rahe:** Metabolic Plasticity in Red-Eyed Treefrog Larvae
- Rachel L. Schilling:** Use of Nonhuman Primates in Search of an Effective Vaccine Against HIV
- Kimberly A. Shapiro:** Effects of Soil Regulation Standards on Remedial Excavation Cost of Brownfield Property
- Denise L. Whited:** Health Information Technology: A Brief Review Exploring the Benefits Achieved by Health Information Technology Solutions and the Challenges Preventing Universal Implementation

2016 ABSTRACTS OF SENIOR RESEARCH PROJECTS (In Alphabetical Order)

Caitlin D. Boyd

Equine Protozoal Myeloencephalitis (EPM): Diagnosis, Epidemiology and Treatment of a Debilitating Equine Disease

Equine protozoal myeloencephalitis (EPM) is a debilitating neurological disease of horses caused by the parasite *Sarcocystis neurona*. The life cycle of *S. neurona* includes an intermediate host (ex: domestic cats, raccoons, skunks) where the sarcocysts multiply, and a definitive host (Opossums, *Didelphis virginiana*) where the parasite reproduces sexually and sheds infective sporocytes. Horses may accidentally ingest the parasite in grain, hay, or pastures contaminated by opossum feces and then become a dead end host for the parasite. Unfortunately, the disease has been hard to diagnose because its physical presentation of ataxia, muscle atrophy, head shaking and other symptoms is similar to that of other unrelated neurological diseases. In addition, treatment options have been limited. This paper reviews the epidemiology of EPM and outlines recent developments in the disease's diagnosis and treatment. The accuracy of EPM diagnosis has increased as Cerebro-Spinal Fluid testing (CSF) has replaced Western Blot analysis and the approval of four new antiprotozoal drugs by the FDA (pyrimethamine, sulfadiazine, ponazuril, diclazuril), along with several drugs under development, offer new hope for effective treatment. The relative efficacy of each treatment is still not known, but ponazuril has had the highest success rate for horses at Otterbein's, Austin E. Knowlton Center for Equine Science.

Breanna C. Brown

Characterization of a Putative Cell Signaling Gene in the Bacterial Plant Pathogen *Streptomyces scabies*

Streptomyces species are gram positive filamentous soil bacteria found worldwide. They are known for their ability to synthesize over two-thirds of the antibiotics in use today. The *Streptomyces* genome is the largest bacterial genome to be sequenced thus far and contains the largest known amount of genes within a single bacterium. Many of these genes are involved in the complex program of development that is characteristic of this bacterial genus. *S. scabies* causes a disease known as "common scab" that affects potatoes and other root grown crops such as beets, radishes, and carrots. SCAB27101 is suspected to make cyclic dimeric guanosine monophosphate (c-di-GMP) which is a bacterial second messenger that controls a variety of cellular processes, including spore production. The gene SCAB27101 was deleted to introduce a new mutation in *S. scabies* using the REDIRECT protocol. A phenotypic

comparison was completed for visual colony morphology and will be extended to include microscopic appearance, ability to make biofilms and ability to infect potatoes and other root crop vegetables. It was hypothesized that the mutation would cause the spores to develop faster as the homologous gene does in the closely related species, *S. coelicolor*. This would in turn make the mutant more pathogenic towards the root crop vegetables. However, the mutation surprisingly had the opposite effect on development and reveals an interesting difference between the two species. The ability to control spore production could allow root grown crops to be more successful and help the agricultural industry as well as the economy.

Claudia E. Buckle

Why was Ebola not contained quickly?

Ebola Hemorrhagic Fever is caused by a virus of the species *Zaire ebolavirus*. It affects both humans and animals, particularly primates. Ebola was first discovered in 1976, near the Ebola River in Zaire. The Ebola outbreak that began in West Africa in early 2014 is the worst outbreak of this virus in history. It took the lives of 11,315 people and there were more than 25,000 laboratories confirmed cases worldwide; Ebola virus is spread when an individual comes in direct contact with bodily fluids known to have the virus from an infected individual. The development period typically lasts for about 5 to 7 days and roughly 90% of the patients see symptoms 21 days after exposure (Dhama, Kuldeep, et al. 2015). This literature review was designed to discover why the most recent outbreaks were not contained as quickly as previous outbreaks. Its conclusions are that Ebola was not controlled swiftly due to a number of factors such as: The extremely mobile populations of Guinea, Liberia, and Sierra Leone; The lack of proper infrastructure such as healthcare facilities and professionals; and the lack of education concerning the Ebola Virus. All three countries didn't have the basic equipment or essential medical supplies to treat patients. Through intense efforts from the global communities and local doctors (World Health Organization, 2015) the recent West African Ebola epidemic was finally contained, but it took several years.

Kelsey L. Burkitt

A Review of Variables Affecting Behavior Differences in Chimpanzees (*Pan troglodytes*) and Bonobos (*Pan paniscus*)

Genetically, chimpanzees and bonobos are the two primates most closely related to humans. Just like humans, these animals rely on their social groups for an array of factors that contribute to their physical and psychological health. Some of these psychological factors affect social development and learning, as well as their decision making ability for their self and others. Social groups play a large role in the physical health and development of strength and nourishment in

individual animals by creating competition for resources. As ecological competition intensifies, these primates also learn to resolve conflict within their social groups. Each of these factors affects behavior in these primates, showing differences between chimpanzees and bonobos. Results of behavioral studies have shown social groupings have an overall positive effect in each primate. The vital role groups play on the overall development of the individual animal outweighs any negative effects associated with or caused by other animals in the same or neighboring social group. Typical behaviors generally displayed by one individual may be affected or altered by the behaviors of another individual when an extended amount of time is spent around one another within their social group. Looking at how these behaviors are affected can benefit us when forming social groups in a captive situation.

Kimberly J. Corr

Effects of Olfactory Stimulation and Environmental Enrichment in Captive Housed Felids

Environmental Enrichment is any technique designed to improve biological functioning of a captive animal with the use of changes to its environment. Recently researchers have started exploring the impact of sensory stimulation, such as olfactory stimulants, as a means of environmental enrichment. Odorants are used to trigger the sense of smell through the use of both biologically relevant and non-biologically relevant odors. This method is used often on captive felids due to the fact that their sense of smell is so developed. By impregnating objects with specific scents and watching to see if the felid has a specific reaction, researchers can determine which scents are stimulating and implement them into the enrichment program, and likewise discard those which have no result. While there were a few outliers that had differing results, in the majority of cases the results found a classic enrichment response, which shows increased activity as well as increased natural behaviors in the felids.

Rachel B. Dalton

A Retrospective Analysis of Trends in Central Ohio Wildlife Health Using Records from a Wildlife Rehabilitation Facility

The analysis of records from wildlife rehabilitation facilities has shown great potential as a technique for monitoring health trends in local wildlife populations. I examined 45,668 records of animals admitted to Ohio Wildlife Center, a wildlife rehabilitation facility located in central Ohio, over a 10 year period (2005-2014). The objective was to examine how causes of admission for commonly admitted species may change over time and co-vary with seasonal patterns, with the goal of using fluctuations in wildlife admissions as a monitoring technique for population and ecosystem health. I assigned causes of admission to broad categories, such as "Collision with Non-Moving Object", and a specific

subcategory, such as “Collision with Window” or “Collision with Power Lines”. Reasons for admission were compared across taxa and the 10 year period. I found that top specific causes for admission exhibited seasonal fluctuations that are consistent with annual biological patterns related to wildlife breeding and migratory seasons. This analysis suggests wildlife rehabilitation records do reflect phenomena occurring in local wildlife populations, supporting the use of wildlife rehabilitation facility data to monitor wildlife health, and potentially influence decision making for wildlife and ecosystem management.

Renae J. Gerchow

North American Wolves as a Model for Increasing Reintroduction Success of African Wild Dogs

Conservation efforts often involve reintroducing endangered animals into their native habitats. Yellowstone National Park gray wolves (*Canis lupus*) were reintroduced by translocating wild wolves from the Jasper National Park in Canada. However, not all species have that option. African Wild Dogs (*Lycan pictus*), red wolves (*Canis rufus*), and Mexican wolves (*Canis lupus baileyi*) have such depleted populations that translocation is not always possible, and releasing captive individuals is necessary. All three species of wolves have been successfully released, but releases of African Wild Dogs have been less successful. This paper compared wolf behavior in captivity and the wild to determine which natural behaviors are important for successful reintroductions. I then used this model to determine which natural behaviors African Wild Dogs are missing in captivity that may contribute to reintroduction failure. I compared data from 34 studies and found that captive and wild wolf packs had similar pack sizes, sex ratios, dominance hierarchies, and aggression. Captive African Wild Dogs differed from their wild populations in terms of sex ratios, resting behavior, and amount of aggression. Relatedness of the breeding pair was also an important trait that could affect behavior. No data was found on relatedness for wolves. These findings can be used to better assess the success of African Wild Dog reintroductions and to guide efforts to increase the prevalence of important behaviors and pack traits in captivity.

Kailey A. Giancola

Anatomical Changes of Cortical Neurons in Rodents with the Presence of Norketamine

Ketamine is a chemical compound that many may be familiar with. It is commonly used as an anesthetic, a street drug nicknamed “Special K” and most recently research has focused on the drugs antidepressant abilities. Ketamine acts as a N-methyl-D-aspartate (NMDA) receptor antagonist that causes an increase in synaptic communication when the neuron becomes excited. A readily available metabolite of Ketamine, Norketamine, is used in this study to

mimic the effects that Ketamine has on the brain in a more readily available setting. Little is known on how Ketamine affects neurons and their anatomy. This research focuses on the anatomy of neurons, the presence of dendritic spines, the degree of dendritic arborization and how the use of Norketamine affects cortical rat neurons. Cortical neurons and Human Embryonic Kidney Cells were grown in culture and their anatomy was studied under an inverted microscope. Norketamine was then added and pictures were taken again showing a change in dendrites correlating to potential changes in synaptic communications. In the future electrical potentials of the cells could be measured and recorded with the presence of Norketamine to evaluate if the compound is inhibiting or exciting the neurons.

Meaghan L. Graver

The Efficacy of Educational Signage in Zoos Regarding the Palm Oil Industry

The rapidly expanding palm oil industry has many deleterious effects on Malaysian ecosystems. Palm oil is a common consumer ingredient but the production of it often results in forest loss in southern Asia and the resultant decline of many animal species. The primary solution to this problem has been to educate companies about the industry and urge them to seek sustainable alternatives. As a further push, consumers are being educated to encourage them to seek and request sustainable products. A primary avenue for this education can be within zoos as they reach a large audience, and their mission hinges on conservation and education. This study examines the educational value of signage within three Ohio AZA accredited zoos by surveying zoo visitors about their palm oil knowledge in relation to zoo signage. Only 5% of visitors indicated that they had read any signage relating to palm oil during their visit. Their reading of the signage did not have a significant impact on their answers to questions on the survey. This study suggests that signage within zoos is not an effective form of education about the palm oil industry, and alternative methods will need to be utilized in order to educate a broad consumer base.

Charles O. Grayson

Fibromyalgia and Rheumatoid Arthritis: Does Weather Affect the Level of Pain Reported by Patients with These Conditions?

The purpose of this lit review is to determine if weather worsens the pain symptoms reported by patients suffering from Fibromyalgia (FM) and Rheumatoid Arthritis (RA). FM and RA patients both suffer from chronic widespread pain (CWP) as determined by the American College of Rheumatology (ACR) (Wolfe, 2003). Many sufferers claim that the severity of their pain is influenced by the weather. Studies done on correlation between weather and pain for these conditions have

shown mixed results. 26 articles ranging from 1996 to 2015 were obtained from a search on PubMed evaluating correlation between weather and pain. 14 articles contained information regarding diagnosis, treatment, and economic impact. Of those 14, 2 studies did not show any correlation. 2 studies showed conditional correlation. Correlation was shown for patients who had RA for more than 10 years. Correlation was shown for patients between the ages of 50-65. 2 studies showed correlation only if the weather variables were humidity and temperature. 3 studies showed that correlation was due to psychological reasons and not to actual data. 3 of the studies did not have enough participants or data for the results to be clinically meaningful. The final determination of the overall assessment of this literature review is that the results vary greatly and that there is still much yet to be discovered about the relationship between weather and pain in patients with FM and RA.

Samantha L. Hargrove

A Pre-human Baseline for Stressors Limiting Staghorn Coral: Evidence from Sub-fossil Skeletons Preserved in Earthquake Scarps, Central Belize

Caribbean coral reefs have had an 80% decrease in live coral cover over the last several decades in part resulting from white-band disease killing most *Acropora* corals. The loss of *Acropora* decreased reef rugosity and eliminated habitat for fish and reef invertebrates. This project examines the record of biological stressors that face *A. cervicornis* by comparing pre-human staghorn communities to extant communities. *A. cervicornis* fragments, estimated to be 250-750 years old, were collected from recently exposed earthquake scarps on patch reefs in the South Water Caye Marine Reserve, Central Belize. Skeletal records of stressors included damsel fish chimneys, clubbed and eroded branch tips attributable to fireworm predation, and resheeting over skeleton killed by snail predation or disease. These results were compared to similar data from live *A. cervicornis* colonies on 18 nearby patch reefs. *A. cervicornis* comprised most of the pre-human assemblage, but makes up only 1% of the live coral cover today. Patch reefs today instead contain high proportions of branching corals with low topographic relief such as *Agaricia tenuifolia* (21%), *Porites porites* (16%) and *Millipora complinata* (fire coral, 15%). Damsel fish impacts did not change from the pre-human baseline, but the incidence of fireworm predation and disease have both more than doubled. Increased biological stressors on *A. cervicornis* may result from a loss of predators such as large fish and lobsters that previously would have eaten fireworms and snails. An increase in fishing regulations within South Water Caye Marine Reserve may be necessary to reestablish thriving staghorn coral communities.

Sarah R. Holbrook

Ebola: A Tale of Two Epidemics and Lessons Learned

The 1995 outbreak of Ebola virus disease (EVD) in the Democratic Republic of Congo (DRC) is considered to be the second deadliest outbreak caused by the *Zaire ebolavirus* (ZEBOV) species. The recent outbreak in West Africa claimed the lives of more than 10,000 people, greatly surpassing previous outbreaks in magnitude and severity. The purpose of this study was to juxtapose the 1995 Kikwit outbreak (KWO) and the 2014 West Africa outbreak (WAO). Through rigorous control interventions, the KWO was contained after six months, while the WAO persisted for nearly 26 months. Viral transmission during the KWO was limited to the Kikwit region, while the WAO affected several African, North American, and European countries. The KWO resulted in 315 cases and 256 deaths, which paled in comparison to the 28,639 cases and 11,316 deaths reported during the WAO. Control and treatment measures during both outbreaks were impeded by similar socioeconomic factors and cultural beliefs. Lack of early containment interventions, understaffed and unprepared healthcare facilities, and lack of public knowledge regarding disease causation in at-risk communities ultimately contributed to the unprecedented size of the WAO. A positive, though costly, effect of the outbreak was new knowledge of the disease for both at-risk communities and local and international public health organizations, which may perhaps aid in the containment of future EVD outbreaks.

Jillian J. Keefer

Resurgence of *Acropora* Species Corals on Mid Shelf Patch Reefs, Southwater Caye Marine Reserve, Central Belize

Acropora cervicornis (staghorn) and *Acropora palmata* (elkhorn) are ecologically important corals that grow quickly and provide topography and refuges for fish and invertebrates. Historically *Acropora* was the most abundant coral in shallow patch reef zones in the Caribbean. During the 1980s, white band disease eliminated most *Acropora* causing a loss in rugosity and an increase of macroalgae on many reefs. Although *Acropora* remains rare throughout most of the Caribbean, this study documents its partial comeback and possible limiting factors in Southwater Caye Marine Reserve (SWCMR), Central Belize. Patch reefs in the reserve averaged 19% live coral cover with *A. palmata* comprising 12% of the total, and *A. cervicornis* 1%. *A. palmata* occurred on 83% of patch reefs with only 9% of colonies having disease and only 12% of recognizable *A. palmata* substrate was dead. *A. cervicornis* occurred on 44% of patches and had 19% dead skeleton and a high incidence of fireworm predation (88% of sites) and lower impacts from predatory snails (25%) and disease (13%). There was no evidence of bleaching. These results suggest that *Acropora palmata* and *A. cervicornis* are beginning to resurge on patch reefs in the SWCMR and that their populations are not primarily limited by disease or bleaching. Colonies are healthy and their numbers are apparently limited by low recruitment and to a

lesser extent predators. SWCMR should enforce tighter fishing restrictions to allow the fish predators of corallivorous snails and fireworms to increase in number thus promoting the spread of *Acropora* corals and an increase in reef rugosity and diversity.

Mollie E. Kemp

Cognition and Problem Solving Using Detour Reaching and Novel Object Tasks in the Budgerigar (*Melopsittacus undulatus*)

As animal cognition is a complex and multifaceted issue, our understanding of the topic is still incomplete. Particularly, our understanding of what factors may drive the development of intricate and costly behaviors relating to cognition, like bird call or song, are not well understood. One possible explanation is the cognitive capacity hypothesis which states that song complexity is a signal of cognitive abilities and thus an indication of a mate's ability to problem solve and thus effectively provide for offspring and mates. However, previous research of this hypothesis has yielded mixed results and has 1) focused solely on male song or calls and 2) runs on the assumption that problem solving ability is not a function of personality, notably the shyness or boldness of an individual. An individual's place on the shy/bold continuum has been established in previous literature via novel object testing. This study tested problem solving ability and its relation to shyness/boldness in 6 female budgerigars (*Melopsittacus undulatus*) by utilizing a detour reaching task and novel object task. From these findings, ability to problem solve was not found to be a function of an individual's shyness or boldness. This highlights the need for further investigation into what other factors may be contributing to problem solving ability and how these factors relate to the costly neural investment necessary for bird song and calls.

Alicia M. Lindberg

A Review of the Secondary Metabolites Fumonisin and Aflatoxin in Food Products

Mycotoxins are natural food and feed supply contaminants that can be found throughout the world and thrive in certain climates and conditions. These mycotoxins form as a secondary metabolite from a fungi. Mycotoxins are detected using antibody assays and chromatography techniques. Once formed the mycotoxins can be ingested, inhaled or absorbed through the skin. This contact can cause a variety of symptoms ranging from a lowered appetite, sickness or even death in both animals and humans. Mycotoxins also have a large effect on economies, especially in farm dependent communities. Developed countries have standards in place as a control for these mycotoxins but underdeveloped or developing countries struggle with these standards, especially in subsistence farming. This literary review is to examine what

mycotoxins are, how they develop, what is done presently to prevent them and what could be improved upon in the future.

Megan K. Locke

Effects of Percutaneous Closure of Patent Ductus Arteriosus in Infants Less than One Year of Age: A Systematic Review

The purpose of this study is to assess the safety and feasibility of percutaneous PDA closure in infants as reported in the available medical literature. Patent ductus arteriosus (PDA) is the continuous opening of the ductus arteriosus in an infant's heart after birth. This, when left untreated, can lead to severe health complications. Historically, the first treatment options to correct PDA were the use of medications and surgical ligation. Percutaneous PDA closure is a newer treatment option that is increasingly performed during infancy (<1 year of age); however, its safety and feasibility is not yet understood in infants. We conducted a systematic review of all pertinent published data. Of 1060 articles identified, only 19 articles met inclusion criteria satisfactorily. Eighteen articles were case-control studies and 1 was a cohort study. No randomized controlled studies were identified. The tally of patients from all 19 articles revealed 505 patients undergoing percutaneous closure of PDA. Of these, 471 (93%) were reported to have attained complete PDA closure. In addition, a total of 154 adverse events (AEs) (30.5%) were identified. Of the total AEs found in the total cohort, 76 (15%) AEs were deemed clinically significant (CS), while 78 (15.4%) were non-clinically significant (NCS). Our systematic review demonstrates the procedure is feasible; nonetheless, there are risks worth noting. Further comparative studies of percutaneous PDA closure with other treatment options (medications or surgery) are vital to better understand which treatment offers the best outcomes for infants.

David B. Monaco

Topography Changes and Their Effects on Tornadogenesis in Ohio

The physical location of the United States along with atmospheric features create a breeding ground for many kinds of weather including tornadoes. However, the United States has unique topographic features which affect severe weather patterns. This paper's purpose is to review the literature regarding tornadogenesis related to changes in topography and the comparison of tornado occurrences across Ohio with respect to the topography of Ohio. The purpose of the study is to determine if topographical elevation changes decrease the likelihood of tornadogenesis. Due to the current understanding, concepts, and physics of basic thunderstorm and supercell thunderstorm development, the hypothesis in this paper is that more severe and dramatic topographical changes do have an adverse effect on tornadogenesis, leading to an apparent absence of tornadoes in these regions. The history of tornado occurrences in Ohio was also

collected from 1950-2012 courtesy of the National Oceanic and Atmospheric Association and this data will be compared to the national history of tornado occurrences as to see if Ohio follows the model of typical tornado events. Many scientific papers published out of universities, scientific communities, and meteorological societies have been reviewed to acquire a consensus on the current state of information on the topic. An adverse correlation between topographical elevation change and tornadogenesis was apparent which makes tornadogenesis significantly less likely when encountering severe elevation changes and higher altitudes. The historical occurrences of tornadoes in Ohio follows this pattern in correlation to the topographical features present in Ohio.

Brent B. Mullin

The Impact of Human Activity on the Populations of Zebra Mussels in Alum Creek Reservoir

Zebra mussels (*Dreissena polymorpha*) are an invasive species of freshwater mussel, originally native to southern Russia. They can become so abundant that they cause ecological and economic damage in areas where they are found. If it were known what makes an area hospitable for zebra mussels, then it might be possible to eradicate them from areas where they are not wanted and concentrate them in areas where they can be grown for specific ecological or industrial applications. This study ascertained whether human activity affected the abundance and growth of zebra mussels in Alum Creek Reservoir. Zebra mussels were collected from 1 m² quadrats at nine locations. After being collected, each mussel was counted and the length and width of 100 random mussels from each sample was measured. It was found that there were less than 10 mussels/m² in the far northern section of the reservoir, between 400-700 mussels/m² in the center section, and less than 200 mussels/m² in the far southern section of the impoundment, nearest to the dam (T-test comparing the mean densities of mussels between the middle and southern sections: $T = 7.242$, $p = 0.0425$). Mussel size was relatively consistent throughout (5-8 mm in width and 11-17 mm in length). The far northern section was essentially devoid of mussels because this portion of the impoundment experiences higher flow and may dry out when the reservoir is drawn down. The higher number of mussels in the mid-section of the reservoir where human activities were greatest suggests that an increase in human activity will not negatively affect these mussels. More research is needed to determine if human activity encourages zebra mussel growth.

Connor E. Musial

Temperature Fluctuations Present in Fractured Aquifer at Remediation Site in Taneytown, Maryland

Groundwater is an important resource that often goes overlooked. These systems can become contaminated when a volatile organic compounds (VOCs) is introduced into the ground water as a result of a spill. It is important to understand the subsurface geology to be able to accurately predict the movement of the groundwater to mitigate the impacts of the spill. A site in Taneytown, Maryland has been undergoing remediation following a spill of Tetrachloroethylene (PCE) on the property. Temperature data loggers were used to record the changes in temperature through the year as well as across pumping cycles. This data was able to show that certain monitoring wells are in fractured rock while others are not. This data would then be used to predict the movement of the plume of PCE within the aquifer to contain the plume on the property. The current method of remediation has substantially reduced the amount of PCE that remains in the aquifer, however it is still not within maximum contamination limits (MCLs). This will lead to a change in strategy to how the contamination area will be further cleaned to meet MCL limits.

Rebecca A. North

Dugong Decline in the Great Barrier Reef

Dugongs (*Dugong dugon*) live in the western Pacific and Indian Oceans and are currently listed as an IUCN Red List species vulnerable to extinction. Initial aerial surveys of the Great Barrier Reef in 1962 suggested a population of 72,000 individuals, but this number has decreased 8.7% per year for 37 years. By the mid-1990s the population was 4,220 individuals and it declined an additional 70% between 2005 and 2011. Several key human and environmental stressors are the primary contributors to the decline. In 2011, 237 dugong deaths were estimated and these included documented cases of 57 from indigenous hunting, 33 from natural causes, and six from human activities. Those dying from natural causes had very low body fat scores and may have been undernourished following widespread seagrass destruction caused by cyclone Yasi. Australia has attempted to mitigate the declining dugong populations by implementing a new zoning plan for the Great Barrier Reef in 2003. This plan protects 96% of the high value dugong habitats and 24% of shallow water seagrass meadows. The Great Barrier Reef Biodiversity Conservation Strategy 2013 recognized that dugongs are still at risk in the Marine Park and have focused their conservation strategy on, engaging the community, building ecosystem resilience, and improving knowledge on Dugong populations

Samantha L Perry

Effects of Enrichment on the Behavioral Activity Budget of Hand-reared Coyotes (*Canis latrans*)

It is well known that captivity can alter the behavior of a multitude of species compared to the behavior of their wild conspecifics. Enrichment is a tool commonly employed by facilities that house wildlife as a method of improving captive animal welfare by altering the environment and husbandry of captive animals in a way that best meets each individual's behavioral and biological needs. This study investigated the effects of enrichment on the behavioral activity budget of captive hand-reared coyotes. I found that stereotypy and aggression between conspecifics significantly decreased when enrichment was present. Exploratory behavior significantly increased when enrichment was present. Physical activity, stand/scan and lay/sit behaviors were not significantly different between sampling periods with and without enrichment. Whether or not the enrichment was food based also had an impact on the frequency that the behaviors were performed. These results suggest enrichment does have a significant impact on the behavioral budget of captive hand-reared coyotes, and different enrichment items can be utilized by facilities depending on the specific needs of the coyotes housed there.

Caitlyn E. Rahe

Metabolic Plasticity in Red-Eyed Treefrog Larvae

Red-eyed tree frog larvae, *Agalychnis callidryas*, reared in competitive environments with low food resources have smaller livers and longer guts than those reared in resource-rich environments. Although these larvae have large gut capacities, they continue to feed at low levels even after *ad libitum* food becomes available. The purpose of this study was to determine if differences in organ size and intake patterns are associated with differences in metabolism induced by the larval environment. In other anuran species, predation threat alters metabolic rate, so the effect of this environmental condition was also studied. Two sets of experimental mesocosms were maintained at the Smithsonian Tropical Research Institute in Gamboa, Panama. The first set housed larvae at low and high densities with a standard amount of food. The second set housed larvae at an intermediate density with and without a caged Belostomatid predator. Once larvae reached a standard size, standard metabolic rate was measured using the Witrox closed-system respirometry. Finally, individuals from the low and high density were moved in groups of five to new mesocosms where they received limited resources. Growth was measured for two weeks. As predicted, larvae raised in low resource environments had lower metabolic rates than those reared with high resources, explaining previously reported intake patterns. Unexpectedly, when larvae were transferred to limited resources, low-density larvae still grew faster than high-density larvae. Metabolic rate did not vary with

predation, but additional studies in which more kairomones are generated are warranted.

Derek Randall

Effects of Enrichment on the Display of Stereotypic and Natural Behaviors of an Amur Tiger (*Panthera tigris altaica*)

Tigers are a critically endangered species due to factors such as poaching, habitat loss and lack of prey. As their population size continues to decrease in the wild, the only way tigers will continue to exist is if they have a stable population in captivity. Keeping species such as tigers in captivity is challenging due to the stresses caused by living in an environment so different than their natural habitat. Welfare is of the utmost concern when keeping animals in captivity. Stress is generally displayed in the form of stereotypic behaviors—behaviors that would not be observed in the wild. One way to minimize the display of stereotypic behaviors is the utilization of enrichment. In this study one Amur tiger at the Columbus Zoo and Aquarium was observed in an outdoor enclosure for a total of 2,513 minutes. All recording was done between the hours of 9am and 3pm in the winter of 2015. All-occurrence recording was used to document behaviors displayed in an effort to analyze the effects of enrichment on the display of stereotypic and natural behaviors and how the presence of enrichment altered the subject's daily activity levels. These data were also used to determine whether different forms of enrichment had different influences on his behavior. The subject spent 29.6% of the observation time in active behavior, 36% in resting behavior, 34% in stereotypic behavior and <1% interacting with enrichment. Enrichment did not affect the behavior of this tiger.

Christopher D. Rapp

Protein Binding to Cyclic di-GMP in *Streptomyces coelicolor*

Streptomyces coelicolor is a Gram positive bacterium that resides in the soil. This bacterium is used in the study of bacterial development and antibiotic production. It has a finished genome sequence and has recently been shown to regulate its complex life cycle via cyclic di-GMP signaling. Cyclic di-GMP is a second messenger that is found within *Streptomyces coelicolor* as well as many other bacteria. The identification of novel cyclic di-GMP binding proteins is the focus of this study. BldD is a protein found within *Streptomyces coelicolor* that is a cyclic di-GMP-binding effector protein. We hypothesize that there are other proteins that also bind to cyclic di-GMP. *Streptomyces coelicolor* was grown on SFM plates, and cells were harvested after a 48 hour incubation period. Once these cells were lysed and isolated by sonication, they were tested for protein concentration via a BCA assay using a spectrophotometer, as well as a Qubit assay which relies on binding of a fluorescent dye that is specific to proteins. The membrane and cytoplasmic fractions of protein were also run on an SDS-PAGE

gel to see that proteins are present before running the capture experiment. Proteins that bind cyclic di-GMP will be captured via the addition of biotinylated cyclic di-GMP and activation under UV light, and then addition of streptavidin-coated magnetic beads. These samples will then be subjected to mass spectrometry for identification. The known cyclic di-GMP binding protein, BldD, and other suspected binding proteins should be captured along with many previously unknown proteins.

Myriah P. Repuyan

Identification and Characterization of *Streptomyces* Transposon Mutants

Streptomyces species are filamentous bacteria responsible for producing most natural antibiotics used in human and veterinary medicine. As an advantage, using *Streptomyces* to analyze gene functions by mutating those genes allows us to understand the role each plays in the complex development of this organism. In our lab we have identified both known and novel genes using random transposon mutagenesis of the wild-type (normal) *Streptomyces* strain. Genes with putative roles in development, such as white genes that are required for normal spore formation and bald genes which are blocked for aerial mycelium formation when mutated have been identified in mutant screens. This study aims to further characterize and determine the functional activity of the genes mutated in four different *Streptomyces* transposon mutants that produce a lower level of the mature spore pigment. The cultured strains were first subjected to chromosomal DNA isolation and restriction enzyme digestion with *Sau3A*I which, was used to recognize and cut a specific sequence. Phenol-chloroform extraction and ethanol precipitation were then used to remove the enzyme. To ligate the DNA strands, *T4* DNA ligase was used, and then followed by an inverse PCR reaction to amplify the unknown sequence. Gel electrophoresis was then performed to observe PCR product and the product was sent for sequencing. Sequences were then analyzed and Basic Local Alignment Search Tool (BLAST) was used to identify transposon insertion sites. New genes that have been recently identified include: a putative monooxygenase gene, an ATP/GTP binding protein and two other hypothetical genes.

Rachel L. Schilling

Use of Nonhuman Primates in Search of an Effective Vaccine Against HIV

The Human Immunodeficiency Virus (HIV) is a highly mutable retrovirus, affecting over 35 million people worldwide and killing over 12 million. The Simian Immunodeficiency Virus (SIV) is known as a precursor or ancestor to HIV, making non-human primates an ideal animal model for HIV vaccine development. Despite benefits for both humans and non-human primates from biological research, the debate over animal use continues, with many studies including disclaimers and ethical statements. The purpose of this study is to

explore and discuss the process of using non-human primates to test experimental vaccines against HIV infection. Non-human primate models share 98% of our genes, and due to successful breeding programs, research is no longer considered a threat to survival. Various federal agencies regulate the use of animals in research, which has lead to less than 0.5% of all animal models being non-human primates. Before animal testing can begin, HIV and common routes of transmission must be understood. If animal trials are successful, a series of human trials can begin. Before approval and licensure, a vaccine must prove to be safe, efficient, and effective as group sizes increase, however post-licensure vaccines continue to be closely monitored. Today, there is still no cure to HIV, but it is through the use of non-human primates that successful human trials have begun to emerge.

Kimberly A. Shapiro

Effects of Soil Regulation Standards on Remedial Excavation Cost of Brownfield Property

Brownfield sites are a common occurrence across the United States and can be costly to remediate (Linn 2013). Brownfields are areas of land which are perceived as contaminated by industrial and commercial processes with hazardous waste. These sites have the potential to be remediated or reclaimed, which is preferred over the development of green space. Green space is land which has yet to be developed or industrialized (Hartmann et al. 2014). The possibility for reclamation of brownfields is site-specific and highly dependent on local conditions. Otterbein currently owns brownfield property which has hazardous waste impacts. The purpose of this study is to determine the cost associated with excavation as the primary remedial technique. The cost will be calculated for two post-remediation land use options to determine if there is a significant difference in cost. It is hypothesized that excavating soils to meet Ohio Voluntary Action Program standards of construction/excavation land use will be less costly than excavating to residential use standards.

Scott M. Shipkowski

Investigation of Shale Gas Drilling and Groundwater Quality, Tioga County, PA

Tioga County, Pennsylvania is an area affected by the recent boom of the hydraulic fracturing industry. The full effect of extracting resources via fracking on local groundwater is still not well understood. This study was developed to better understand fracking's potential effect on ground water, and to assess potential risks to the health and safety of Tioga County citizens. To assess groundwater, homeowner's wells in Tioga County were chosen for sampling using a randomization process. The levels of common analytes associated with fracking operations (e.g. Barium, chlorides, methane, etc.) were analyzed to assess water

quality. One hundred wells were chosen for testing with 50 wells within 400 meters of the fracking wells and 50 wells greater than 400 meters from the wells. Samples were collected using the homeowners pumping system and a multi-parameter water quality field meter was used to quantify parameters such as dissolved oxygen, conductivity and pH. Water samples were delivered to the lab for analysis for analyte concentrations. Results indicate that all parameters were below EPA Maximum Contaminant Levels (MCL). There were more detections of methane, in the wells within 400 meters of the fracking wells. However methane concentrations were well below accepted standards. It was concluded that no consistent groundwater impact that may affect citizen's health and safety were identified. The methane detections in homeowner wells within 400 m of fracking wells may be related to fracking operations, but there was not a consistent pattern of methane detection in the closer wells. This study serves as a baseline for water quality in an area where fracking is prevalent, future sampling events will be used to determine if long-term impacts occur.

Macie D. Smith

Personality in Giant Panda (*Ailuropoda melanoleuca*) Cubs across Different Environmental Contexts

Many animals exhibit consistent individual differences in average frequencies of behavior in a range of environmental contexts. These animal personalities influence survival, reproduction, and the ability to acquire resources, and thus are a target for selection. This study aims to identify the existence of personality in zoo housed giant panda cubs by quantifying individual differences in behavior patterns in different contexts. Contexts of focus include time of day, the number of pandas in the enclosure, and whether or not the pandas were on public display. A total of 97 hours of observational data was collected and analyzed for five one year old giant panda cubs at the Chengdu Research Base of Giant Panda Breeding in Chengdu, Sichuan, China. Overall, the giant panda cubs spent the majority of all observation periods resting and engaged in social behaviors. Higher frequencies of active and play behaviors were observed in the mornings while more resting behaviors occurred in the afternoons. Social and non-social behaviors differed significantly between locations with more non-social behaviors occurring in private areas and more social behaviors occurring in public. Social, non-social, active, and resting behaviors differed significantly between individual pandas. The number of pandas present in the enclosure did not significantly affect behavioral frequencies. These data indicate the existence of personality in giant panda cubs, which can later be used as a tool for selecting appropriate individuals for successful reintroductions.

Trevor S. Smoot

A Comparative Analysis of Fish and Mussels in Lower Big Walnut Creek

Freshwater mussels (family Unionidae) depend on fish as hosts for their larval (glochidia) stage. Where fish communities are diverse and numbers of fish are abundant, mussel communities also may thrive. Mussel diversity in Big Walnut Creek downstream of Hoover Dam can be divided into three reaches: an upper reach where historic and extant mussel diversity are relatively similar (85% similarity), a middle reach where extant mussel diversity is lower than historical diversity (58% similarity), and a lower reach that is somewhat intermediate in regard to diversity of historical and extant mussel species (70% similarity). Because of the relationship mussels have with fish, the hypothesis is that fish community parameters mirror mussel community parameters. Fish were collected by using an electrofisher employing Ohio EPA methodology at sites where mussels also had been collected. The fish data were used to calculate fish-IBI and Shannon-Weiner Diversity Index values. These data were compared to mussel-IBI, Shannon-Weiner Diversity Index, and Jaccard Coefficient of Similarity values for the mussel communities previously determined. Linear regression was used to compare fish and mussel parameters. Fish-IBI and Shannon-Weiner Diversity Index values remained relatively high (ranged 42-56 and 2.28-2.88 respectively) throughout the reach from the dam to near the mouth while mussel parameters did not (IBI ranged 16-36; SWDI ranged 0-1.03; Jaccard ranged 57%-100%). Fish community structure does not explain the loss of mussels in the mid-section of lower Big Walnut Creek.

Morgan A. Stark

Determination of Cyclic-di-GMP- Controlled Gene Expression in a pharmacologically Important Bacterium

The second messenger molecule cyclic dimeric GMP (c-di-GMP) regulates a myriad of processes in gram-negative bacteria. However, less is known about the roles it plays in gram-positive bacteria. Differential gene expression in three strains of the gram-positive bacterium, *Streptomyces coelicolor*, is being studied using RNA sequencing and Real Time PCR to gain insight into c-di-GMP signaling. The *rmdA rmdB* (regulator of morphology and development) double mutant was compared to the wild type strain known as MT1110. The *rmdA* and *rmdB* genes are needed for the formation of aerial mycelium, an important step in the life cycle of *Streptomyces coelicolor*. A diguanylate cyclase mutant was also compared to the wild type strain of *S. coelicolor*. The RNA sequencing experiment revealed that 3,151 genes are differentially expressed in the phosphodiesterase double mutant and 1,341 genes are differentially expressed in the diguanylate cyclase mutant when both mutants are compared to the wild type strain of *S. coelicolor*. Both known and uncharacterized genes were found in the data to be differentially expressed. Genes of interest for future study were also identified. In particular, the *chaplin* genes were found to be expressed at

significantly lower levels in the phosphodiesterase double mutant as predicted prior to completing the experiment. The chaplins are critical protein players in the formation of aerial hyphae. Real Time PCR experiments are currently being conducted to confirm the results obtained using RNA sequencing.

Cory R. Usher

Growth Rate Plasticity in Larval Northern Leopard Frogs

Compensatory growth is rapid growth after a period of growth depression. We studied growth rates of Northern Leopard frog tadpoles (*Lithobates pipiens*) after a period of growth depression induced by predation or competition. I predicted that tadpoles in treatments with high competition would have long guts that facilitated compensatory growth. I also predicted that tadpoles exposed to predation would have short guts that would prevent compensatory growth. Tadpoles were reared at low and high density in 410 L mesocosms with and without a caged predator. Each treatment was replicated 5 times. When tadpoles reached 4cm in length, 3 tadpoles from each treatment were transferred to a new mesocosm with *ad libitum* food and no predators. They were allowed to grow for one week. Initially, tadpoles reared without predators grew faster, but no tadpoles showed signs of compensatory growth post transfer. Unexpectedly, high competition tadpoles had a greater intake than low competition tadpoles, but grew more slowly. Tadpoles reared without predators had longer tails than those reared with predators, but there was no difference in gut length between any treatments. Cold temperatures during the first weeks of the study could have affected the results. Nonetheless, larvae did exhibit a high degree of growth-rate plasticity.

Matthew K. Vieth

Effects of Browse and Behavior on Fecal Constitution of African Elephants in a Zoo Setting

Housing elephants in zoos is a controversial issue; discussions of elephant welfare are paramount in the zoological community. A convenient way to monitor their welfare is needed, and one way to do so is through monitoring the consistency of their feces. This study looks to see how browse, a form of enrichment, and social behavior in a herd of African elephants affects their fecal constitution. To do this, affiliative and non-affiliative behavioral interactions were recorded six days a week between 8:30AM-12:00PM over the course of four weeks in the summer of 2015. Type of browse and quantity were also recorded. Fecals were scored on each elephant three times a day for each day of observations on a scale of 1-5 with one being liquid and five being bolus firm. Overall fecal scores of elephants were found to vary across individuals. Behavioral interaction had no effect on fecal consistency, and browse appears to have almost no impact with the exception of a negative correlation with the

amount of bottletree consumed. This indicates that any type of approved browse, with the potential notable exception of bottletree can be given in the quantities from this study without affecting their fecal consistency, and that social grouping does not have a detectable effect on this method of evaluating elephant welfare.

Denise L. Whited

Health Information Technology: A Brief Review Exploring the Benefits Achieved by Health Information Technology Solutions and the Challenges Preventing Universal Implementation

The world of healthcare has changed significantly through the years with the integration of information technology solutions. A review of literature related to health information technology has determined that incorporating technological solutions in the healthcare industry can lead to such benefits as a decrease in medical errors, decrease in medical costs to patients and healthcare organizations, an increase in patient involvement in their medical management, and the opportunity to provide medical care to areas lacking medical expertise or resources. Computerized physician ordering, medication prescribing, and clinical decision support systems have been shown to decrease medical errors by checking medication dose, frequency and route, drug interactions and patient allergies. Telemedicine solutions, such as email, text messaging, video conferencing and electronic health records, allow patients to be more engaged in their healthcare and can provide medical access across geographical limitations. Despite these positive benefits, health information technology adoption is not yet universal. Implementation in poor areas and developing countries is particularly challenging. Unfortunately the areas that need the benefits of health information technology solutions the most, such as developing countries, are the ones most disadvantaged, as they may lack even basic electricity. Other challenges facing implementation can include the lack of finances or resources, political constraints, legal concerns, and negative patient or healthcare provider perceptions. Finding ways to overcome these obstacles is not easy, but will allow a faster adoption of information technology solutions in healthcare, leading to more equality in healthcare opportunities and better health outcomes for patients across the world.

Nicholas P. Wilburn

The Effects of Immediate Land use on the Distribution and Abundance of Aquatic Insect Larvae in the Lower Big Walnut Creek

Aquatic insect larvae can be observed in a wide range of North American freshwater ecosystems. Due to their wide distribution, they can be used to understand the health of the ecosystem and the impact of human activities, such as land use adjacent to these freshwater habitats. Therefore, the objective of this study was to evaluate the immediate land use effects on aquatic insect larvae in

the Lower Big Walnut Creek. Hester-Dendy Multiplate sampling devices were placed in the creek at two locations in the Lower Big Walnut Creek in Southeastern Franklin County, Ohio. These plates were left in the creek for approximately sixty days. Land use adjacent to the upstream sample location was forested on both banks and land use along the downstream sample location was bordered on the north by agriculture and on the south by quarries. The two locations had nine and five replicates, respectively. The larvae that colonized the plates were preserved in 70% ethanol and brought back to the laboratory for identification. Even though all four family-level taxa were found both upstream and downstream, the number of individuals found on the plates upstream were significantly higher than those found adjacent to the farm field and quarry ($T = 3.22426$, $p < 0.05$). These results suggest that immediate land use does affect the abundance of insects.

Dr. David Sheridan and BIO 3998 students (Fall 2015)

Effects of Age, Sex, Weight, and Hand Dominance on Hand Grip Strength

Understanding grip strength is important for researchers, medical professionals, and rehabilitators. There are many functional, clinical, psychological, and psychosocial variables that can affect grip strength (Hogrel, 2015). Measuring grip strength, such as with the MP36 Biopac units and force transducers, can be a good indicator of overall body strength and can help predict disability and recovery rate (Al-Obaidi, *et al.*, 2014). We hypothesized that age would affect grip strength and predicted that grip strength would peak between 20-40 years of age and decline after 40 years, since there is typically a decline in musculoskeletal strength and mass as humans age and therefore less motor units (Martin, *et al.*, 2015). We also hypothesized that sex would influence grip strength and predicted that males, on average, would have a stronger grip because males, on average, have more muscle mass and therefore more motor units (Maden-Wilkinson, *et al.*, 2015). Our research determined that significant relationships exist between certain variables and grip strength. We determined that men were stronger than women, but also discovered that middle-aged individuals were stronger than college-aged individuals and subjects over the age of 60.

