

"Feeling" the Heat: Using Thermal Infrared to Understand *Cucurbita pepo*'s Response to Drought

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Crop production can be impeded by a variety of stressors such as drought and disease, and the early detection of crop stress in the field via high-throughput and non-destructive techniques such as infrared (IR) thermography and radiometry can rapidly inform responses to poor crop health. IR radiometry was employed to examine leaf temperature responses of *Cucurbita pepo* to drought and a carbon sink manipulation at the leaf scale. The direct crop water stress index (CWSId) was used as a water stress index to investigate plant responses to drought, with drought being primarily measured by the difference of leaf temperature from ambient temperature (Tleafair). ANOVA and Tukey statistical tests identified a significant increase in temperature difference from ambient in both drought ($p < 0.001$) and carbon sink manipulation ($p < 0.001$) treatment groups, though larger in the droughted group. Two-way ANOVA testing identified an additive model where both treatment and plot position have a significant effect on Tleafair, and no significant interaction is identified. CWSId was successfully correlated with leaf temperature and Tleafair, with the strongest overall correlation between CWSId and leaf temperature ($r = 0.71$). Simple linear regression was employed to predict CWSId based on leaf temperature and Tleafair, where control and carbon sink groups were best predicted by Tleafair, while droughted CWSId was best predicted by raw leaf temperature. This demonstrates how IR thermography for the quick evaluation of crop water stress produces useful results using CWSId, refining two different measurement approaches for researchers and industrialized agricultural operations.

Paciulli Labs NO/NOP Project

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Paciulli Labs in close association with the Duke Lemur center are attempting to decipher the many of various aye-aye (*Daubentonia madagascarensis*) vocalizations in the context of novel object and novel people

Coquerel's Sifakas (*Propithecus coquereli*) Responses to a Novel vs Familiar Person

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Animals explore novel objects to learn new things. Humans are novel objects to most animals. Not much research has been conducted on how lemurs respond to novel people. Therefore, in this study, the response of Coquerel's sifakas (*Propithecus coquereli*) to novel vs. familiar people was examined. The hypothesis was that the Coquerel's sifakas will be curious and willing to approach and/or interact more with a novel person than a familiar one. Data collected at Duke Lemur Center to measure the reactions of Coquerel's sifakas to novel vs. familiar people. Overall, the results of the study were inconclusive. Further research could help better introduce novel people to captive sifakas to reduce stress levels.

Behavioral Markers of Stress in Separated Captive Female and Male Ring-tailed Lemurs (*Lemur catta*)

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In animals, stress is mediated by social and physiological factors. Although it is clear that subordinates are particularly vulnerable to stress, little is known about the relationship between stress and social rank in female-dominant species, such as lemurs. Therefore, in this study, the frequency of stress-related behaviors was examined in five male-female pairs of ring-tailed lemurs (*Lemur catta*) at the Duke Lemur Center in Durham, N.C. The lemurs were video-recorded while separated from their companions for 15 minutes. Previously established markers of anxiety (e.g., vocalizations, pacing, scratching) were coded, and the Mann-Whitney U test and Audacity software were used to analyze the data. The results showed that males scent-marked significantly more than females ($p < 0.0009$). Although not significant, females scratched, paced, and emitted more "high-arousal" calls than males. Also, both sexes vocalized at similar rates, and mean levels of anxiety were higher in females. Thus, social dominance did not appear to reduce stress.

A possible explanation is that female ring-tailed lemurs, like top-ranking male baboons (*Papio anubis*), are more susceptible to stress during periods of social instability. This would imply that the female ring-tailed lemurs experienced more stress when separated from their partner-males than vice versa. Limitations of the study include the small sample size and lack of control of potentially confounding variables such as age, gonadal status, and health. Future research should incorporate larger sample sizes and better control of confounding variables.

Captive Ring-tailed Lemur (*Lemur catta*) Vocalizations When Separated from Group

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Stress is affected by social factors, yet underexplored in female-dominant species. In this study, five male/female pairs of ring-tailed lemurs (*Lemur catta*) were separated for five minutes, and their vocalizations were recorded and coded. The lemurs mostly made aroused vocalizations, and females made more group alert calls than males, likely because they are dominant, and are responsible for group coherency. Also, click and gulp spectrogram shapes differed from those in previous literature. Future research should include longer trials, and compare captive calls with wild vocalizations.

The Effects of Active Particles on Granular Materials

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By introducing active particles into a granular material, we increase the flow rate of the system. We use *Tribolium confusum* larvae as our active particles, and seek to understand how individual motion of active particles affects the macroscopic motion of its environment. We apply two methods to characterize the relevant timescales. To quantify particle scale activity, we use diffusing wave spectroscopy to identify larvae motion. To quantify the bulk flow, we designed an apparatus that measures the flattening of a pile over time. We report that both timescales decrease (faster flow) as the fraction larvae present increases. We also report that flow rate is increased as particle size increases.

The Effect of Flat vs Curved Geometries on Fluttering-Fin Canard Configurations in Missiles

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Recent flow modeling software are adept at visualizing flows around static objects. However, much computing time and error are incurred when motion relative to the fluid flow begins. Improved CFD software pertaining to guidance, navigation, and controls will help predict the outcomes of many canard and other fin-type configurations in missiles, rockets, and canard aircraft. Data on the behavior of supersonic fins and wings in motion will provide a strong background of information upon which future simulations can be built to run smoothly and quickly, and comparisons between flat and curved models will give insight into how aerodynamicists can optimize lift and drag characteristics of their missiles. This study seeks to provide this information through the use of particle image velocimetry (PIV) and/or pressure sensitive paint (PSP).

The Christmas Tree Seed: A Story of a Miniature Wasp and its Parasitoid

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Real Christmas trees are one of the leading sources of profit for farmers in North Carolina and a fundamental component of North American's culture for over a century. We documented the presence of two seed-parasitic insects, *Megastigmus* and their parasitoid *Mesopolobus*, as the only two seed parasites in a clonal seed orchard (CSO) in Creston, North Carolina. Both parasites prevent trees from successfully germinating due to a permanent damage of the seed's embryo and endosperm. We are conducting a 3-year study that follows the application of an insecticide mixture in combination with a gravity seed cleaning method to reduce the number of

infested seeds before and after seed collection in a Fraser fir CSO in Creston, North Carolina. We will provide information to growers about the effectiveness of these two methods to control the presence of both parasites in CSOs and storage seeds for commercialization. We will determine the infestation rates in 15 Fraser fir clones by two methods, dissection of immature seeds and X-radiographies of mature seeds. Additionally, we will test the effect of X-ray electromagnetic radiation on chalcid development and seed germination. Our long-term goal is to identify infestation patterns and the correlation between infestation rates and clones with reduce susceptibility to chalcid seed infestation.

Responses of Male and Female Crowned Lemurs to a Novel Object

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Behavioral research towards a novel object was conducted at the Duke Lemur Center to determine if there was a female hierarchy present in Crowned Lemurs. The methods used to study this, were to take a control object and a novel object, in this case a metal food bowl and baby toy drum, and see how quickly an individual approached the object. This was done in 5 minute trials, which consisted of 5 minute video recordings of nothing, control and then novel objects. The results concluded that females took a shorter period of time to approach the novel object compared to males, and that the females spent a greater amount of time with the object. This shows that there is a correlation between a female hierarchical social setting and the approach of a novel object.

Differences in Bold Personality Traits Among Female and Male Coquerel's Sifakas

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Personality can be defined as the sum total of an individual's behavioral characteristics. Personality describes and accounts for temporally stable patterns of affect, cognition, and behavior (Gosling 2008). Like humans, animals have personalities, too. For example, boldness, curiosity, and inquisition are types of personalities that animals can have. Boldness in animals can be expressed via risk-taking behavior, while inquisition would be demonstrated by prolonged investigation or cross-examination of a novel object (Verdolin pers. comm.). Also, curiosity could be a display of a desire to acquire new skills or knowledge (Verdolin pers. comm.). For example, Wilson et al. (1994) found that generally animals are bold when they approach new objects or explore new and unfamiliar environments

Males and females exhibit differences in personalities, as well. For instance, Byrnes et al. (1999) found that male humans (*Homo sapiens*) were more likely to take risks in comparison to females, and this pattern increased when people were stressed. Likewise, Dammhahn (2012) examined sex differences in personalities of mouse lemurs (*Microcebus murinus*) using open field tests to quantify behaviors that were related to activity and exploration in a novel environment. She found that males were generally more bold than females. One reason for females being less bold is likely that they were busy investing in reproductive and maternal behaviors (Dammhahn 2012).

In this study, sex differences in personality will be examined by observing a Coquerel's sifaka (*Propithecus coquereli*) group. Specifically, traits related to boldness such as inquisitiveness and curiosity will be recorded. In addition, keepers' ratings of the same group of sifakas will be used to further ascertain the animals' personalities. The hypothesis is that because female sifakas are more involved in maternal behaviors than males, males will exhibit more bold behaviors than females, including having more incidents of curiosity and inquisition.

Responses of Aye-ayes (*Daubentonia madagascariensis*) to a Silver Object and a Blue Object

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Opsin genes determine four different types of color vision. The aye-aye contains the SWS1 opsin gene, which may allow them to see the color blue. This could serve as a selective foraging advantage. However, it is unknown if this gene is functionally important. It was hypothesized that aye-ayes will be able to see the color blue, and therefore react more to the color. Two males and two females were presented with a silver orb and a blue orb under ~1 lux lighting, simulating moonlight, and their responses were recorded. It was found that on average, subjects spent more time with the blue orb than the silver one.. This suggests aye-ayes can differentiate the color blue from other colors, which may give them an advantage in foraging activities.

Ontogeny of Infant Aye-Aye Vocalizations

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Vocalizations are a vital part of communication for many species. In particular, some species' infants rely heavily on vocalizations to survive their first days of life. The aye-aye (*Daubentonia madagascariensis*) is a nocturnal prosimian, and not much is known about their vocalizations. To date, only two studies have been conducted on aye-aye calls, and both were published almost 25 years ago. Stanger and Macedonia (1994) reported that aye-ayes have six vocalizations - scream, plea, whimper, sneeze, snort, and screech, while Winn (1994) found that infants produced four vocalizations - creee, fuff, ron-tsit, and hoo-hoo. Infants made two fewer calls than adults, and all four vocalizations had not been heard in adults. Therefore, in this study, the ontogeny of infant vocalizations was examined in one captive female aye-aye, Agatha, at the Duke Lemur Center. A Sennheiser ME66 condenser microphone was placed in the infant aye-aye's nest box to record any sounds made. Vocalizations were captured and stored in audio-files. Adobe Audition was used to listen to and code the type of call. The results showed that Agatha emitted her first vocalization within two hours of birth, when she eeped. Agatha also drummed and huffed. Therefore, of the four adult aye-aye vocalizations previously reported, Agatha made three of them. The missing / fourth adult vocalization is an ack, which is an estrous call, made during sexual receptivity. These results contradict previous reports that infant aye-ayes make different vocalizations than adults. Future research should include increasing the sample size and data collection period.