CORNELL LANDS FIELD PROJECT REPORT

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TITLE: Disruption of Health and Performance by Artificial Light at Night

NATURAL AREAS:
Eames Bog, McLean Bog, Etna Preserve, Ellis Hollow Wetlands

PROJECT DURATION:
July 1st - November 15th, 2019; January 1st - March 15th, 2020

OBJECTIVES:
Artificial light at night (ALAN) has the potential to upend organisms' physiology and behavior by disrupting their natural biological rhythms entrained by celestial light. Solar and lunar cycles commonly control processes such as hormone release and activity time in many species, impacting performance and survival. In this multi-year study, I investigate whether ALAN directly impacts learning and performance and whether this happens through the disruption of lunar rhythms or circadian rhythms. I test these questions in free-living Black-capped Chickadees (*Poecile atricapillus*) experimentally exposed to natural and artificial light in a feeder-based study. I intend to understand whether ALAN alters the ability to learn about and track novel food resources and whether these impacts may be due to a disruption of natural rhythms. This will be the first study to rigorously assess the relationship between ALAN, circadian rhythm and daily learning performance in a free-living organism.

This study will compose the majority of the work for my PhD dissertation in Ecology and Evolutionary Biology. The results of this study will increase our understanding of human impacts on wildlife, specifically the impacts of light pollution of wildlife behavior. The implications of this study will be immediately useful for managers and other scientists in the field.

RESEARCH METHODS AND PROCEDURES:
I conducted this study in four study sites surrounding Ithaca, N.Y: Ellis Hollow Wetlands, McLean Bog, Warren Woods and Eames Bog. I installed feeders late in the autumn of 2019 at each site to monitor chickadee behavior in the coming winter. Beginning in January 2020, lighted two of these sites artificially with solar battery-powered flood lights: Warren Woods and Eames Bog. I concluded the experimental light treatment in March 2020.

To quantify activity, I monitored birds using radio frequency identification (RFID) technology. I tagged 10-15 birds at each site with passive integrated transponder tags encoded with unique identifiers in the summer and fall of 2019. RFID antennae and boards attached to feeders recorded activity when birds visited the feeders, giving information on individual identification and precise time of feeding. These data will supply number of feeder visits per day and approximate activity levels, resulting in quantified chronotype variation over the lunar cycle and during the 24-hour cycle.

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Each study site had six feeders with monitoring equipment. Two empty feeders represented background bird activity, one feeder with high quality food, one feeder with medium quality food and two feeders that formerly housed food. The high-quality feeder had mealworms mixed in with seed and the lower-quality feeder only black-oil sunflower seed. Ten more feeders were also placed throughout each site as blanks without food or technology. Every four days, I swapped batteries, downloaded data, switched feeder roles and checked on technology. Other technology included continuous monitoring devices: HOBO temperature and light sensor and Swift bioacoustic monitoring units.

DESCRIPTION OF ACTIVITIES:
From July 1st to November 15th, I captured chickadees to tag and take measurements. I placed USGS aluminum bands and PIT tag bands on captured birds and took morphological and blood measurements. I worked far off trail to avoid any intervention from the public to increase avian safety and capture success. I worked with up to 4 other assistants to capture birds, all fellow PhD students.

During this period, I also installed equipment in my four sites. At Warren Woods and Eames Bog, I installed 20 flood lights approximately 3 meters high in trees in a gridded fashion. Lights were strapped to trees, so that no damage was done to the trees. I climbed a ladder to place trees and brought a spotter during all installations. At all sites, I place 16 feeders, 6 with RFID enabled technology and batteries, 2 that were filled at any time. These were also installed in a gridded fashion, with lights hung on 10 ft poles that had been dug 1 ft into the ground which were also equipped with conical squirrel baffles. 3 HOBO recorders were place on feeders at each site and 3 Swift recorders were placed at each site (non-invasively strapped to trees). All equipment was distinctly installed off trail and away from site edges. Each site had 1 sign and 1 pamphlet with contact, project and website information. All technology went ‘live’ on January 20th, 2020. All equipment was removed from the site prior to March 30th, 2020. Apart from installation and tear-down, which at times required work parties up to 6 people, I had two field assistants during data recording periods.

MAJOR HIGHLIGHTS:
The morphology and avian community of the Warren Woods site was perfect for the study. The size and distance from other forested patches kept the birds localized to the tracking technology, while the birds themselves participated in several, gregarious mixed-species flocks. Human impact was relatively low at this site, with some interspersed hunting in a portion of the woods and few runners and off-leash dogs.

The ease of access to sites was helpful during periods of nice, dry weather. Neighbors and contacts for each site were relatively available for communication. Fred Whitsett of McLean Bog was especially helpful, providing an alternative access point to the bog through his private land, as well as information on the natural history of the area.

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ISSUES ENCOUNTERED:

Several sites were thoroughly traveled by the public. Warren Woods and Ellis Hollow Wetlands had many hikers, runners and dogs off-leash--therefore, the technology was exposed to many people. Theft was unfortunately one encountered issue, although it was thankfully not a consistent one. Equipment did not show consistent issues of tampering. Neighboring feeders may have distracted from study results, but this was an off site issue.

Non-human neighbors were also a consistent issue. Bear and deer tampered with equipment to a mild extent. Squirrels were especially prevalent at Eames Bog, where the forest was dense. While squirrels were an issue at all sites, the squirrels at Eames made it a particularly unsuccessful site, as they attacked technology persistently and ruined several feeders.

This past winter was especially warm and inconsistent in temperature. This caused variation in the available diet for birds and may have led to variation in their response and attachment to feeders. The large masting of 2019 was likely another factor with similar results. The warming and cooling cycles tended to push the feeder poles out of the ground, since the sites were wet and the ground expanded and contracted with temperature changes. Habitat different between the sites also led to variation in results for reasons similar to impact of climate variation on avian behavior. Overall, these issues resulted in variation in feeder visitation between sites, and low visitation overall.

Inconsistent weather and distance from other populations made access difficult for several of the sites. Durland Preserve (EHW) had a small parking lot that was not maintained after snowfall, making parking impossible during periods of heavy snow. It's continued use is tenuous due to lack of access. Other sites also had difficult access, which maintains a need for a four-wheel drive, high clearance vehicle--all-wheel drive is not sufficient.

POTENTIAL SOLUTIONS FOR FUTURE SEASONS:

Many issues encountered do not have clear solutions, for climate and habitat-based issues are not easily solved. However, the season could be lengthened and more feeder training prior to the experiment could increase the likelihood of birds visiting feeders and increase overall data consumption. This could cushion any future natural issues that may occur in future seasons. Switching to different sites and increasing site number could also increase success of the project. Eames Bog, for example, could be dropped as a site since it was completely unsuccessful. Overall, a longer season with more undergraduate support could greatly increase the project's success.

ECOSYSTEM IMPACT:

There was no clear ecosystem impact from the study, that would be long-lasting. However, the study focused on the impacts of artificial light at night on birds in natural environments. Therefore, it is likely that light had an impact on the ecosystem during the

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study extent. Other equipment was installed in as non-invasive fashion as possible. No holes were drilled into trees and the only marks remaining were trampled vegetation and small holes in the ground from feeder poles. Care was taken not to create extensive social paths and to preserve vegetation. All equipment was removed at the end of the season.