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Annotated Bibliography #1

Scientific Article Notes /Ann. Bibliography

Citation:

URL: https://www.scielo.br/j/zool/a/mw9sJprpmdMBZKFhKtKx7GG/?lang=en

Date of Publication: May 9th, 2013

Title: Biology and life table of Dirphia araucaria (Lepidoptera: Saturniidae): A herbivore of potentially high impact on Araucaria Angustifolia (forest)

Journal: published on Zoologia (Curitiba)

Volume: 30

Issue: 2

Page #s: 7 (143-150)

Key Words: Atlantic Forest; conservation biology; developmental biology; forest entomology; Pinheiro-do-Paraná; South America, instar

General Subject: Biology

Specific Subjects: the life span, and trend of moths, specifically the Dirphia araucaria. The experiment studies several life trends including, development period, survival rate, growth rate, weight as a young moth.

Hypothesis/Question: How do the conditions Dirphis araucaria are put under effect, their impact on the Araucaria Angustifolia. (there was not a specific hypothesis)

Methodology: the experiment was done under controlled conditions in a lab where the eggs of the moths were put in a plastic cup lined with moist paper, and they determined the fertility and duration of “egg state” by counting the number of eggs that became larvae, out of 25 total eggs. The larvae are fed fresh leaves and additional twigs. During the larvae state data is collected from 186 larvae of the hatched larvae, the larvae are transferred to new twigs and individual cups, and monitored separately. This process was repeated over time and unfortunately, 56 larvae died during this time. They monitored the survival rate of each larva, and the growth of the larvae by dividing the average head capsules width of the next instar by the average head capsules width of the previous instar. Other things they measured were biotic potential and fertility.

Materials: In this experiment, they used plastic cups and coverings to hold the larvae and moths in, as well as an environment/ lab that was easy to control the weather of. They used sticks and plants to put in each of the larva containers so they could eat. Lastly, they used graphs to record the growth and lifespan of each larva and moth.

Results: The moths lived 18 days longer than they were previously thought to, this is because of two reasons: 1) the areas from where they collected the moths/larvae were Scientific Article differences, and 2) differences between rearing conditions- of infant care of the larvae. Throughout this experiment, they found that in 25 degrees celsius weather the female moths would live between 110-140 days, and found a higher fertility rate in these conditions, that could be affected by their more free lifestyle or lack of disease because of the controlled conditions they were kept under. During the larval stage, it appeared that the female took longer to develop than the males. All 398 larvae from the clusters did move on to the pupal stage however the sex ratio between them had ranged from 0.34- 0.58, and the last change was those female pupals were heavier than males. The reason that the life span stated above is so short for adults is that they do not feed and instead focus on reproduction. However, they found that the life span was significantly longer in females than in males. As far as biotic potential goes the moths reached their highest point of the population during the 5th and 6th days of their adult life.

Summary of Key points: This article showed the lifespan of moths and what conditions they will live to their full biotic potential under. This will help me because I will be able to use this information to set up a healthy living environment when working with my moths. In the article, they mentioned the amount of time a moth of the species will live and how to increase this time. Examples of this are how they found that female moths would live better in 25 degree celsius temperature and that would allow them to live 110-140 days. This is important because it gives me a time frame to conduct my experiment. It also brought up the differences in female and male moths, including the wide range of sex from the larvae to the pupal stages, and how female pupals are heavier than male pupals.

Important Figures: (page numbers N/A)

Figure 1: This is a very important figure because it shows the percentage of time each stage of the moth's life takes compared to the total life span.
Figure 2-7: this is just a picture of the different stages of life the moth they experimented on goes through
Figure 8: relation of fertility rate and survival rate
Table 1: shows the mean survival rate of the months in days.
Table 2: the duration of instar and larvae stages for females and males.
Table 3: the mean capsule width and growth of each instar for females and males
Table 4: mean duration of pupal stage and larval and mean pupal weight for females and males.
Table 5: average lifespan for males and females

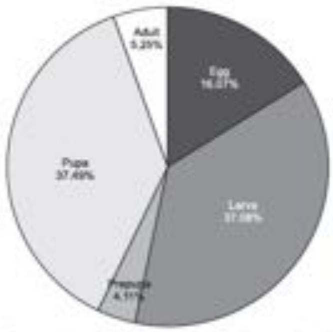


Figure 1. Proportion of each developmental stage in relation to the whole life cycle duration of *Dirphia araucariae* reared at 20 ± 1°C, 70 ± 10% RU with 12:12 photoperiod.

Table I. Survival rate and mean duration of each developmental stage of *Dirphia araucariae* reared at 20 ± 1°C, 70 ± 10% RU with 12:12 photoperiod.

Development stage	N (initial-final)	Survival (%)	Duration (days)	Range (days)
Total	–	76.94	166.62	–
Adult	26	–	8.38 ± 2.10	5-12
Pupa	104-104	100.00	62.462 ± 7.45	46-79
Prepupa	124-104	83.87	6.846 ± 1.16	4-9
Larva	130-124	95.39	61.779 ± 2.43	57-69
Egg	6784-6510	96.18	26.779 ± 0.39	25-29

Table V. Average life span for adult females and males, duration of oviposition period (in days) and fecundity of 20 couples of *Dirphia araucariae* reared at 20 ± 1°C, 70 ± 10% RU with 12:12 photoperiod.

Sex	Parameter	Mean	Range
Female	Life span *	9.85 ± 1.75	6-12
	Total Fecundity[1+2]	358.45 ± 48.73	238-425
	Fecundity (laid eggs)[1]	302.55 ± 74.25	142-412
	Fecundity (eggs held in the abdomen)[2]	55.90 ± 46.82	0-201
	Postoviposition	1.15 ± 0.93	0-2
	Oviposition	6.6 ± 2.18	3-10
	Preoviposition	2.1 ± 0.30	2-3
Male	Life span *	6.9 ± 1.16	5-9

Means were compared by the Student's t-test, at a significance level of $p < 0.05$ (ns = $p > 0.05$; * $p < 0.05$).

Table II. Duration of each larval instar and prepupa stage for females and males of *Dirphia araucariae* reared at 20 ± 1°C, 70 ± 10% RU with 12:12 photoperiod.

Developmental stage	Duration (days)		
	Females (56)	Males (48)	Significance
I	14.21 ± 1.09	13.89 ± 0.85	ns
II	7.66 ± 0.51	7.48 ± 0.65	ns
III	7.96 ± 0.63	7.75 ± 0.63	ns
IV	8.76 ± 0.78	8.45 ± 0.74	*
V	11.93 ± 1.09	11.43 ± 1.07	*
VI	12.18 ± 0.81	11.66 ± 1.07	**
Prepupa	6.98 ± 1.21	6.68 ± 1.09	ns
Total	69.69 ± 2.58	67.37 ± 2.02	**

Means were compared by the Student's t-test, at a significance level of $p < 0.05$ (ns $p > 0.05$; * $p < 0.05$; ** $p < 0.01$).

Table IV. Mean duration (in days) of pupal stage and larval + pupal stage, and mean pupal weight for females and males of *Dirphia araucariae* reared at 20 ± 1°C, 70 ± 10% RU with 12:12 photoperiod.

Parameter	Female (108)	Range	Male (120)	Range	Significance
Pupal stage	61.05 ± 7.73	46-79	64.10 ± 6.83	48-79	*
Pupal + larval stage	130.75 ± 7.96	114-149	131.48 ± 7.46	115-148	ns
Pupal weight	5.36 ± 0.592	2.69-6.26	3.70 ± 0.50	2.40-4.79	*

Means were compared by the Student's t-test, at a significance level of $P < 0.05$ (ns $p > 0.05$; * $p < 0.05$).

Reasoning: this particular ex[pierement was aimed to understand this species of moth and their effect on the forest, they found that this population size will not have a bad effect on the forest. Lastly, they needed to run more tests to understand the biological differences based on their geographical regions.

Annotated Bibliography #2

Scientific Article Notes /Ann. Bibliography

Citation:

URL: https://www.eje.cz/pdfs/eje/2016/01/65.pdf

Date of Publication: September 27, 2016

Title: Settling moths as potential pollinators of Uncaria rhynchophylla (Rubiaceae)

Journal: European Journal of Entomology

Volume: 113

Issue: #1

Page #s: 5

Key Words: Lepidoptera, Crambidae, Geometridae, Erebidae, Noctuidae, floral visitors, generalized pollination system, nocturnal moths

General Subject: Zoology

Specific Subjects: the pollination patterns of settling moths

Hypothesis/Question: To conclude whether or not nocturnal moths are important pollinators

Methodology: This experiment was conducted in a warm temperate area, with large amounts of vegetation. Researchers walked along a path with this vegetation and recorded which pollinators they saw in the area; these surveys were conducted on several days in June. During this, they sampled the insects using insect nets to sample pollen grain. These grains were put under a microscope and counted and recorded the number of present pollen and pollen that was not found on some insects but found on others. Then they randomly sampled 9 flowers, and measured their lengths, and tested the amount of nectar.

Materials: the plant Rubiaceae and insect nets, slide calipers, or with an ocular micrometer under a stereomicroscope, ruler.

Results: They are just as important to pollinations as diurnal pollinators. They found that both nocturnal and diurnal, insects carried over 100 pollen grains. They theorized that moths could be more effective pollinators because they would not clog the flower through interspecific pollen transfer, and the flower held more nectar during the night.

Summary: This experiment was a survey of which pollinators visited certain plants in a set area. Then these pollinators, both nocturnal and diurnal insects were researched and they used the information to take more surveys. They used all of this to understand if nocturnal moths are important pollinators and found through pollen grain samples that they are just as important as diurnal pollinators. This experiment will be very helpful to me because it is more simplified and will be closer to how I run my experiment.

Important Figures:

Figure 1: This is a set of pictures to show the anatomy of the flower as it related to the pollinators and then the grain they find on the pollinators. (page 2)
Table 1: the survey from the pollinators visiting the flowers (page 3)
Table 2: the amount of pollen attached to the pollinators (visiters) (page 3)

Reasoning: This shows that if we need more pollinators perhaps putting certain color light outside that is not as harsh but will attract more moths could help plants

Annotated Bibliography #3

Scientific Article Notes /Ann. Bibliography

Citation: URL:
https://ojs.openagrar.de/index.php/Kulturpflanzenjournal/article/view/13255/13013

Date of Publication:

May 1st, 2017

Title: Observations on the seasonal flight activity of the box tree pyralid Cydalima perspectalis (Lepidoptera: Crambidae) in the Rhine-Main Region of Hessia

Journal: Journal of Cultivated Plants

Volume: 69

Issue: #5

Page #s: 9

Key Words: Box tree moth, light- and pheromone traps, flight activity, melanic morph

General Subject: Agriculture, Biology

Specific Subjects: zoology, Moths flight patterns

Hypothesis/Question: What are the seasonal, yearly flight patterns of moths in a highly infested area? (I could not find a specific hypothesis in the article but this was the general question)

Methodology: The set up this experiment in two places where the plants had high infestation rates from the moths. In these spots, they set up light traps (using the material listed below), and surveyed the spots from May/June to September/ October. They surveyed for moth flight patterns and checked the traps daily for any caught moths. With the caught moths they surveyed for sex, the number of caught moths, and wing color. Then in 2013 and 2015, they used pheromone trapping to survey seasonal flight patterns, (however, they found that the light/ funnel traps were more suited for this experiment). They placed the pheromone traps about 1.6 meters high on a tree and about 25-100 meters apart depending on location. To analyze the "count data" of the moths they caught within a year they used a "Chi-squared test" with given probabilities and took a sample test to compare.

Materials: light trap, plastic "catch" tray, two NARVA Colourlux plus bulbs, plate (for protection against rain), pheromone traps

Results: For seasonal flight activity they found that the first flight phase was in mid-June until late July. During this phase, they saw adults from overwintering, and then a drop-off when the catch decreased in early August and late July. The second flight phase was longer and lasted until mid-August to October (an extension of a month). During this time they saw a large number of catches during September. For the first light traps, there was not much difference between the two sights as far as catches go. Ex: most of the moths that were caught were white-winged moths. They also found that more males were caught than females (combined white and brown winged moths). More white moths were caught than brown moths, and the number of brown moths did decrease a bit during the second flight phase.

Summary: This experiment tested/ surveyed the seasonal flight patterns of moths by using light traps and pheromone traps. They were able to identify two main flight patterns in June- July and late/mid-August- October. This will help me with my experiment because it can show me when the best times to take surveys are or when I have the biggest amount to survey from. There were also collections of data that I could use including sex ratio and color of moths that visited.

Important Figures:
Figure 1: is pretty simple, its pictures of the light and pheromone traps (page 2)
Figure 2: pictures of the morphological varieties of different sex and colored moths (page 2)
Figure 3: seasonal flight activity when looking at the pheromone traps between 2013-2015 (page 4)
Figure 4: seasonal flight activity when looking at the light trap between 2012-2014 (page 4)
Figure 5: Mean proportion [in percentages of the brown variety of moths per month, caught moths between 2013- 2014 from pheromone and light trap (page 6)
Table 1: first catch of the moth's recorded seasonal flight activity of pheromone and light traps (page 5)
Table 2: records from the first and second flight phase including the sex ratios and color ratios, from the light traps (page 5)
Table 3: Occurrence white and brown moths' proportions during the two flight phases detected by pheromone trapping 2013-2014 (page 6)
Table 4: Number of C. perspectalis (moths) generations per year for different countries and regions, (will be very helpful)

Note to Self: they did run into a couple of misfortunes when vandalism caused a decrease in catches during 2014

Reasoning: this study gives good examples of how to monitor the moths successfully, and could relate to my study in the way that if a certain color light was out in these areas, it could keep the moths from infecting more of the plants.

Annotated Bibliography #4

Scientific Article Notes /Ann. Bibliography Name: Mercedes Shay Period: 4

Citation: URL: https://esajournals.onlinelibrary.wiley.com/doi/epdf/10.1002/ecs2.2550

Date of Publication: January 2019

Title: Effects of street lighting technologies on the success and quality of pollination in a nocturnally pollinated plant

Journal: Ecosphere

Volume: 10

Issue: #1

Page #s: 16

Key Words: artificial light at night; environmental change; flowers; Lepidoptera; light pollution; moths; FN, PN, HPS, and LED lights

General Subject: Biology

Specific Subjects: ecology, light pollution, biology

Hypothesis/Question: They had three main questions: What are the relative contributions of diurnal and nocturnal pollinators to the pollination of S. latifolia? What are the effects of FN and PN street lighting on pollination of S. latifolia, compared to unlit controls? And, what are the effects of different types of street lighting technology on pollination of S. latifolia, comparing FN lighting to PN lighting and HPS lights to LEDs?

Methodology: Using S. Latifolia (a native wildflower to Eurasia), they conducted a bioassay of its pollination (the measurement of the concentration of a substance by its effect on living cells). This flower was chosen because it can be pollinated by diurnal and nocturnal pollinators. The seeds were germinated and grown separately then organized into bags to prevent insects from getting to them before the initial experiment. The experiment was conducted in field margins at Molescroft Grange Farm, the pots were put in the margins of two adjacent fields, one with wheat and the other with grass mix for hay production. Each “experimental run” lasted for four days and nights, starting and ending at midday, with favorable weather for pollinator success, during June, July, and August. The pots were placed at an equal distance apart and female plants were enclosed in net cages. They used lights that simulated the change in street lighting (high-pressure sodium lights or light-emitting diodes) so the four forms of lighting that were used are HPS-FN, HPS-PN, LED-FN, and LED-PN. These were used with lighting rigs in the same field margins as the plants and floodlights were mounted to tripods. After the experiment, both males and females were moved back to the greenhouse. And pollination success was determined by the development of one or more seeds in the capsules, and the mass of these capsules was recorded.

Materials: S. Latifolia seeds and a glasshouse, 7 * 7cm pots, bamboo canes, organza bags

Results: (sample size was 417) Total of 194 flowers were fully pollinated and 46 flowers had parasites, so they could only measure seed weight for 148 flowers. The flowers were successfully pollinated by both diurnal and nocturnal pollinators. They found the best success when the flowers openly pollinated (uncaged) and had access to both kinds of pollinators. When looking at the two kinds of pollinators separately, the nocturnal pollinators had more success/ higher rates of pollination. An example of these pollinators is moths! Pollination success was higher under FN lighting, however, the seed count did not change much when the flowers were unlit. Under PN lighting there was no change in pollination, seed count, or seed mass (compared to unlit flowers) . Pollination success was much higher under FN lighting than PN. The seed count was higher under HPS lights than LEDs when under FN lighting. When reusing the plants, they found that the more use it underwent the lower the sea count and mass became. And this is also reflective of the pollination levels for the plants.

Summary: This experiment showed how light pollution could affect pollinators like moths, using the addition of light and a control group without light (also different versions of light). The moths they tested on Nocturnal Lepidoptera (moths) are very important to the pollination process and they used artificial light like the ones you would see at night on streets because this is what would have affected them the most. They thought that this kind of lighting would hurt the pollination process but instead the flowers were pollinated successfully under PN (part- night , some light) and FN light (full night, no light). However, the lamp type, lighting regime and distance from light all affected the quality of pollination. The end result was that street lighting could affect the pollination and therefore reproduction of a plant. This could help my experiment for the reasoning part, to explain why colored lighting is important.

Important Figures:

Figure 1: this is a plot graph showing the light output of experimental lights and the intensity. Then the second graph shows the distance from the light compared to the light's intensity. (page 5)
Figure 2: this bar graph shows the relative contributions of nocturnal and diurnal moths affecting the success in pollination of a plant (page 8)
Figure 3: This is a bar graph showing the effects of lighting treatments compared to the effect on pollination success, and compared to the predictions they originally had (page 9)
Figures 4 and 5: show the effects of lighting on the pollination success but also the seed count and dry mass of seeds per capsule. (page 9)
Figure 4 pt 2: this shows the sme data compared to the “no light” graphs (page 10)

Figure 5 pt 2: shows the effects of different types of street lighting technology on three different types of pollination success and duality (page 11)
Figure 6: this is another bar graph that shows how the lamp type and distance affects the dry mass of seeds per capsule.

Note to Self: summary of this article is that nocturnal moths pollinated better under unlit controls rather than lit controls.

Reasoning: this could show the effects of light population on the environment and how important pollinators like moths are to the ecosystem.

Annotated Bibliography #5

Scientific Article Notes /Ann. Bibliography

Citation: URL: https://www.mdpi.com/2075-4450/10/9/262/htm

Date of Publication: August 22, 2019

Title: Optical Modeling and Phylogenetic Analysis Provide Clues to the Likely Function of Corneal Nipple Arrays in Butterflies and Moths

Journal: Insects

Volume: 10

Issue: #9

Page #s: 15

Key Words: compound eyes, Lepidopters evolution, reflectance, UV lights, eye nipples

General Subject: Sciences; Biology

Specific Subjects: Zoology, Anatomy of Moths

Hypothesis/Question: weather differences in the length and slope of corneal nipples correlates with the evolutionary development of the different lepidopteran families and other differences in characteristics.

Methodology: Eyes of old moths were put under a microscope to examine, for whether they had been damaged due to old age, the eyes were not damaged with age. twenty -two species were examined, 5 diurnal and 17 nocturnal. They looked at the surface of the eyes as well as the cross-section of the eyes. The stimulations were created by a multilayer model simulating the “graded refractive index layers” (these go from the top of the nipple to the base). To study the volume fraction calculations, the “refractive index” of the corneal nipple was taken to a different microscope and studied separately. Then they used SEM to focus on the nipple heights, the distance between adjacent nipples. There was only a slight variation of sizes in tall nipple sections, but in shorter nipple sections there was more variety. The next simulation imitated normal incident light at an angle meant to match the angle of the sun and this was added to the simulation model.

Materials: electron microscopes, Scanning Electron Microscope (SEM).

Results: Heights and arrays of the nipples vary between the species studies, and even within one month family they are not arranged in a common order, After the phylogeny, there were no major effects of diel activity pattern on the nipple height. The diel- (period of 24 hours) flight activity was found to have a significant effect on the top area. For example; Nocturnal species had larger nipple areas and in the males of the Lasiocampa Quercus and Saturnia pavonia species (the males are diurnal) they had no nipples. The reflectance of light is proportional when there are reduced gaps and taller nipples, except in visible light when reflection is greatest for long nipples. The amount of light a moth reflects and absorbs, and how sensitive it is is dependent on the structure of the eye under the nipple, the refraction into the eye structure. Reflectance is least at the UV end of the light spectrum. ONE OF THE REASONS THAT MOTHS COULD BE ATTRACTED TO MAN-MADE LIGHT IS BECAUSE UV WAVELENGTHS ARE PRESENT IN MAN-MADE LIGHT. Night-flying species have larger nipple areas in their eyes.

Summary: This experiment broke down the anatomy of a moth's eye to understand why nocturnal and diurnal moths are attracted to lights. THe used high-powered microscopes to look at the eye's nipple height and surface area and how this affected its absorption or reflection of light. Because the moths were dead and could not have a living reaction to the light, they used a 3D optic modeling to show a simulated example or how this would work. They found that ONE OF THE REASONS THAT MOTHS COULD BE ATTRACTED TO MAN-MADE LIGHT IS BECAUSE UV WAVELENGTHS ARE PRESENT IN MAN-MADE LIGHT. (very important for my project). Something interesting they found is that the species with these corneal nipples could be able to see clearly even when covered in water, this is because the effective refractive index at the end of the nipples is very close to the refractive index of water.

Important Figures: (no page numbers in the version i had to look at)
Figure 1: shows the geometric profile of three different groups of nipple height, with half-width. The other part of the figure shows a Graph of effective refractive index as a function of height, showing the refractive index of water. (c-e show nipple pattern dimensions and effective refractive index layers and shows simulation where incident light waves only see the layers of effective refractive index)
Figure 2: shows images of the corneal nipple array for different species, both male and female.
Figure 3: shows the corneal nipple height data in three groups arranged according to the taxonomic order.
Figure 4: height/area ratio against nocturnal and diurnal activity period for eight species (four diurnal and 4 nocturnal)
Figure 5: graph showing the simulated reflectance of the three different nipple heights, with dimensions and effective refractive index

Note: (abstract) mentioned how they found reduced reflectances = a greater absorption of UV light, which could be the reason why moths are more attracted to UV light. Also, note when working with moths the anatomy of nocturnal moths' eyes is different from the anatomy of a diurnal species.

Reasoning: This will help me with background information for my project.

Introduction/ Rational

The first articles I used for background information in my article discussed the life span and importance of moths as pollinators. The first of these articles came from the Journal of "Zoologia" and discusses the life span of moths and what conditions they will need to live to their full biotic potential ("Biology and life table of Dirphia araucaria (Lepidoptera: Saturniidae): A herbivore of potentially high impact on Araucaria angustifolia" by Mauricio Zenker, Alexandre Specht, Edegar Fronza, Graziela Poletto, Fernanda Marcon, Aline Formentini and Mateus Gedoz). Examples of this are how they found that female moths would live better in 25 degree celsius temperature and that would allow them to live 110-140 days. The next article, on "the Journal of Cultivated Plants" tested/ surveyed the seasonal flight patterns of moths are by using light traps and pheromone traps ("Observations on the seasonal flight activity of the box tree pyralid Cydalima perspectalis (Lepidoptera: Crambidae) in the Rhine-Main Region of Hessia", by Erfassung der saisonalen, and Flugaktivität des Buchsbaum). Through this they found that there are two main flight patterns: in June- July and late/mid-August- October. They took surveys of the moth's sex, color, and frequency of being in a particular area. These articles will give me the necessary background information to explain the basic actions of moths compared to what I observe.

The next two articles I used showed the way a moth's eyes react to different levels of light and the way different amounts of light could affect their pollination. The first of these articles was posted on the journal "Ecosphere" and showed how light pollution could affect pollinators like moths, by adding light or taking away light for different groups of Nocturnal Lepidoptera (moths)("Effects of street lighting technologies on the success and quality of pollination in a nocturnally pollinated plant", by Callum Macgregor, Micheal Pockock, Richard Fox, and Darren Evans).They found that contrary to what they thought, artificial light (like the kind you would see at night- street lamps) did not affect the pollination process of the moths, and they were able to successfully pollinate the plant. However, this experiment did reveal that the lamp type, lighting regime, and distance from light all affected the quality of pollination. Overall, they found that this proved street lighting could affect the pollination and therefore reproduction of plants. The next article, which was posted on the journal "Insects", discussed why moths are attracted to some forms of light by breaking down the anatomy of a moth's eyes ("Optic Modeling and Phylogenetic Analysis Provide Clues to the Likely Function of Corneal Nipple Arrays in Butterflies and Moths," by Adrian Spalding, Katie Shank, on Bennie, Ursula Potter and Richard Constant). They looked at the eyes of diurnal and nocturnal eyes under microscopes and used 3D-optic model programs to simulate the reflection of light. One important thing they found out throughout this experiment is that one of the reasons that moths could be attracted to man-made light is because UV wavelength is present in man-made lights. This will help me to explain why my project is testable, and give an explanation to which lights the moths are attracted to and why.

The last article I used for my background research came from the "European Journal of Entomology", and is a survey of which pollinators (with a focus on moths) visited plants in a control area (“Settling moths as potential pollinators of Uncaria rhynchophylla (Rubiaceae)” by Daichi Funamoto and Shinji Suguria). They did this over several weeks and took surveys of both diurnal and nocturnal moths. Their goal was to understand if nocturnal moths were as important to the pollination system as diurnal moths. To figure this out they took samples of pollen grains found on moths and counted them under a microscope. At the end of this experiment, they found that nocturnal moths are just as important to pollinations as diurnal pollinators and that both nocturnal and diurnal, insects carried over 100 pollen grains from the plants. This will help me to understand and explain why this experiment is important to do.

This research is important to understand how moths are important and why we should think about the amount of light we are emitting into our environment. Moths are, especially nocturnal ones, very important pollinators because they can boost the pollination process. Moths are efficient pollinators because they do not clog the pollination process and carry just as many pollen grains as other diurnal pollinators. This research connected to my project by understanding what kind of lights moths are attracted to. That will help us further understand if our artificial light would have an effect on moths and therefore their pollination process.

This research could have social effects on everyday life, because if it becomes true that the type of light we use does affect the pollination process of moths and other important pollinators then it could be important to consider a change of the lighting we use. The amount and kind of lighting we use could negatively affect the pollination process of moths which can affect the reproduction and growth of plants that we need. Another way this might affect our lives could be beneficial, for example, much of the light we use today is harmful and contributes to light pollution. If needed, changing this light could create a better environment and would not harm the insects we need to sustain the plants around us.

***revised on January 25, 2022**

Research Question

Research Question: The purpose of this project was to determine if the color of LED lights that Acheta domesticus are shown has an effect on the number of Acheta domesticus attracted to the light, and to compare these findings to the ways (moths) are attracted to light.

Independent Variable: the color of LED lights shown to the *crickets

Dependent Variable: the number of Acheta domesticus attracted (clustered around) the light

***revised on January 6, 2022**
***revised on January 25, 2022**
***revised December 7, 2021**

Procedures

1. The Insect Habitat was set up according to included instructions when purchased
2. A piece of rectangular cardboard was added in the middle of the habitat to block the light from one side*
3. The Insect Habitat was moved to a room with controllable lighting (able to be completely dark and light could be let in when necessary)
4. The room was given natural lighting for the Acheta domesticus (house crickets)
5. Slowly the crickets were transferred with care and according to best instruction.
6. The Insects Habitat was closed and the crickets were left to adjust.
7. LED lights were moved close to the Insect Habitat, but were not turned on yet
8. crickets have been given 30 minutes* to settle in
9. The room was darkened and LED lights were turned to 1st setting (purple)
10. crickets were allowed 10 minutes to be drawn toward or away from light
11. The crickets were counted according to how many were drawn toward the specific light color (first, purple), then this data was recorded on data tables
12. Lights were turned off for 10 minutes so crickets could re-adjust*
13. For the next three tests step 11 was repeated but with a different color (red)*
14. Step 13 was repeated (color change to green)
15. Steps 12-14 were repeated two more times (purple, then red, then green)*

***revised on January 25, 2022**

Data Analysis Procedure and Risk and Saftey

Data Analysis Procedure:

1. The rickets are left in the dark for 10 minutes before each color switch and their placement is recorded
2. The room was darkened and LED lights were turned to the first color setting, this color is used for the following test as well then the color is changed and the pattern is repeated
3. Data is recorded based on how many of the 16 Acheta domesticus are drawn (stationed near to the light) toward the light
4. three separate tables are made for day one, day two, and day three

Example (this three times):

Test 1: Color of Light	Purple	Red	Green
Number of Acheta domesticus drawn to light (out of 10 total moths)			
Number of crickets near light before lights are turned on			

Risks and Saftey:

- Possible risk to Acheta domesticus (house crickets), if light harms them
- Possible risk to people if lighting overheats and burns out or catches fire

* edited on February 6, 2022

Materials *

Materials List:

- LED lights with remote control and at minimum 3 color settings (in this case: purple, red, green)
- The Insect Habitat
- Acheta domesticus (house crickets) (live)
- Data tables (as shown above)
- Room with light control
- Food for crickets

Parent Signature:

Brian Shay 12/1/21

***revised on January 25, 2022**

***revised on February 6, 2022**

Data Tables for Tests 1-3*

Test 1: recording how many (out of ten) Acheta domesticus (house crickets) are drawn to the 3 colors of LED lights over a period of 10 minutes

Test 1: Color of Light	Purple	Red	Green
Number of crickets drawn to light (out of 16 total crickets)	3/16	8/16	4/16
Number of crickets near light before lights are turned on	7/16	4/16	8/16

Test 2: recording how many (out of sixteen) Acheta domesticus (house crickets) are drawn to the light

Test 2: Color of Light	Purple	Red	Green
Number of crickets drawn to light (out of 16 total crickets)	6/16	7/16	5/16
Number of crickets near light before lights are turned on	7/16	8/16	8/16

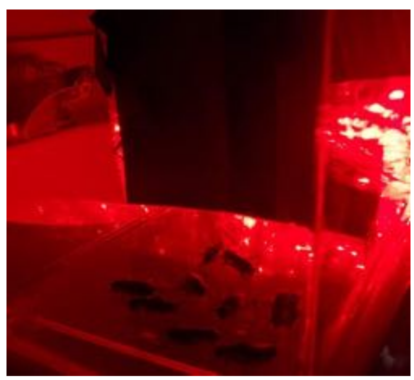
Test 3: recording how many (out of ten) Acheta domesticus (house crickets) are drawn to the light

Test 3: Color of Light	Purple	Red	Green
Number of crickets drawn to light (out of 16 total crickets)	6/16	2/16	4/16
Number of crickets near light before lights are turned on	5/16	2/16	2/16

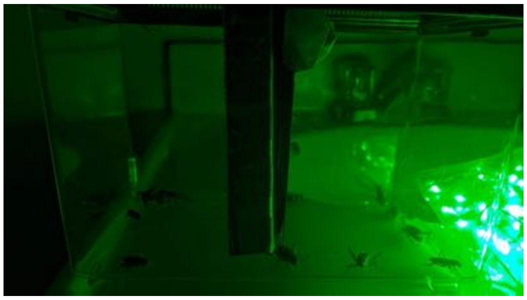
Observations:

During the Purple Light: the crickets became more active over time, and even began to interact with each other. As they crawled closer to the light, they would group with others near them. However, after a short time near the light they move away from it.

During the Red Light: There was much less movement and most crickets stayed completely still for the majority of the time. The only movement was when crickets would slowly cross toward the light and then remain inactive for the remaining time.

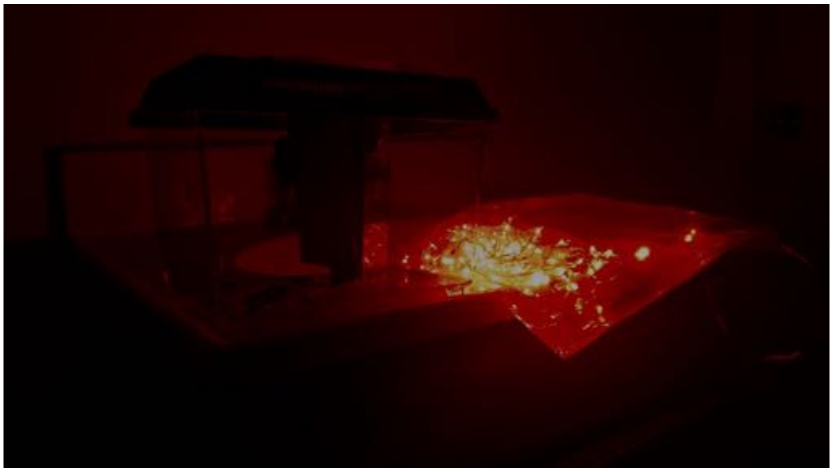


During the Green Light: Almost immediately moved away from the Green light, more movement in between the dark and light corners of the habitat but they ended up on the dark side away from the light. During the 2nd Trial of Green Light the crickets began to make noise and form groups that they remained in for most of trial 3.

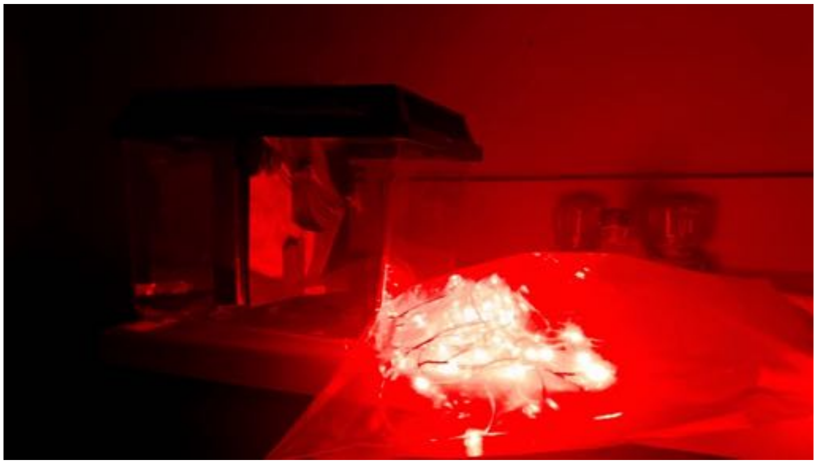


***revised on February 6, 2022**

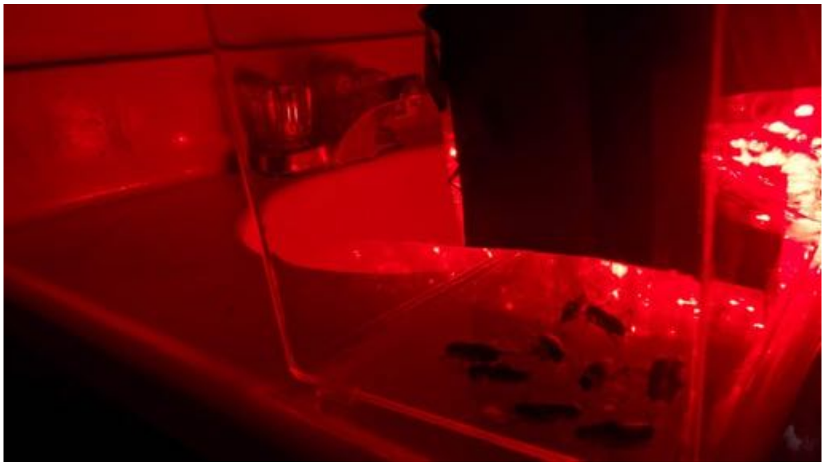
Images for Red Light



The red light phase of the first trial. (above)



The red light phase for the second trial (above).



Red light phase for third trial (above)

Images for Purple Lights

Image of purple light phase for trial 1 (above)

Image for purple light phase for trial 2 (above)

Image for purple light phase for trial 3 (above)

Images for Green Lights

Image for green light phase for trial 1 (above)

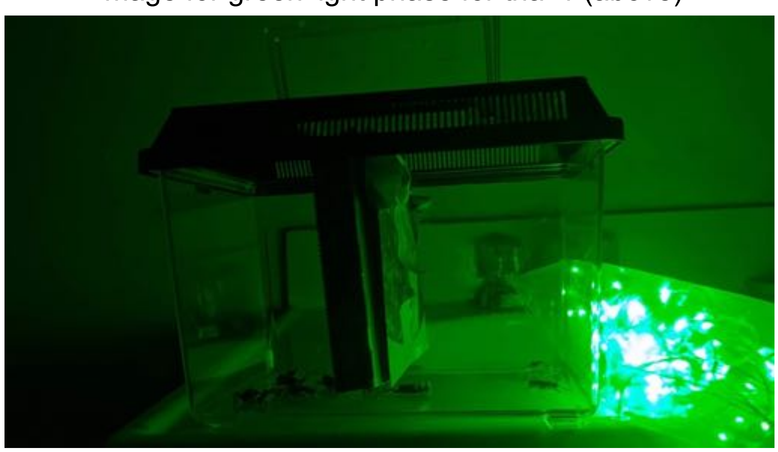


Image for green light phase for trial 2 (above)

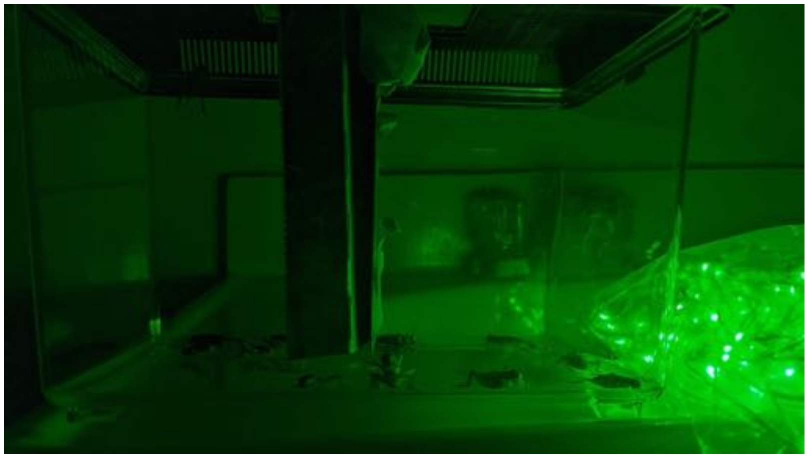


Image for green light phase for trial 3 (above)

Data and Graphs:

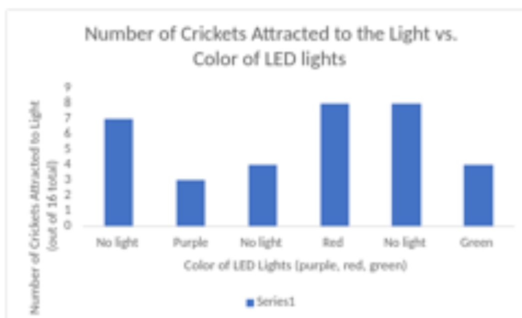


Figure a.: This is a graph of the data taken in trial 1. The data shown on this graph maps how the crickets moved away from the purple LED light, toward the red light and away from the green light.* (above)

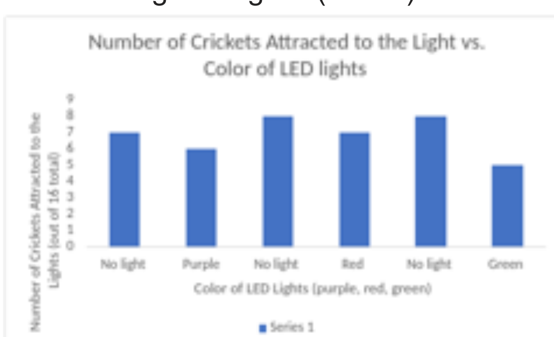


Figure b.: This is a graph of the data taken in trial 2. This graph shows a change in the crickets behavior as they are attracted to the purple, red and green light. The red light showed similar results as the phase with no light.

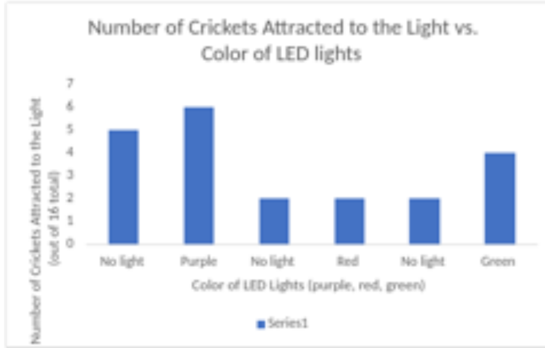


Figure c.: This is a graph of the data taken in trial 3. This graph demonstrates the crickets' consistent attraction to the purple and green light, and the lack of reaction to the red light.

Possible Errors and Affects:

With the possibility of the LED lights bleeding into the other side of the habitat, the results of my experiment might have been changed because the crickets could have seen/ reacted to light on either side. If the crickets were shocked by the sudden change of light this might have affected how quickly or in what ways they reacted to the light. Lastly, the period of darkness could have been interrupted when the door to the room opened, this could have made the crickets move before an accurate count was made

Results:

While the crickets were in the Purple LED light, they became more active and engaged with each other more often. This reaction repeated when they were exposed to the Green LED lights. However, while they were in the Red LED lights, there was a lack of movement and interaction and they still for the majority of the time unless moving towards or away from light. This shows that Crickets have a similar reaction to bright lights as moths, proving my hypothesis correct. However, this experiment brought different results because the crickets had little or no reaction to the red light. This is because crickets are limited in sight when it comes to darker colors and lights, and cannot see the color red.

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Conclusions:

Moths are nocturnal insects and use the moon to navigate during the night. Therefore when brighter lights are shown to moths, it confuses their navigational patterns. Crickets are also nocturnal and show the same behavioral patterns when it comes to the brightness of light they are shown. This explains the data gathered in the three trials for purple and green light. During the red light phase of each trial the behavior of the crickets was very similar to their activity and configuration when in darkness for 10 minutes. This could be explained by crickets lack of vision when it comes to red light. Crickets can see many colors but red, especially when it is a darker red light, as used in this experiment.

Discussions:

The outcome of this experiment helped to prove my hypothesis because it shows that crickets were drawn to the purple and green lights, which are the brighter of the two. When observing the crickets adjust to the purple light, they became more active and interacted with each other more.This was reflected in the green light and continued throughout the three trials, which showed that the Crickets were more attracted and active when exposed to bright light. This was further confirmed when the crickets showed little to no movement in the red light. The data from our experiment was compared to the background research of moths' reaction to light. This data and research supported my hypothesis by showing that crickets react to bright lights in a similar way as moths, because both are nocturnal and are drawn to the brighter lights for safety and navigational reasons.

Real World Application:

Nocturnal insects like moths and crickets use natural lights to navigate in the dark. However, man made lights have disturbed this process, by interfering with their instincts, interrupting the pollination process of Nocturnal Insects like moths. Therefore, if we want to maintain and better the amount of pollination plants in our environments get, we need to reduce our use of man made lights that interrupt the pollination patterns of nocturnal Insects. Furthermore, other experiments that might aid in proving this would be to compare the pollination of moths under man made light to those under natural/ moon light. This would help to demonstrate how destructive bright lights like LEDs can be to nocturnal insects behavioral patterns.

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Links for Slide Deck Background information/ images:

.-Crickets Response to Light (extra article for background research)
-image of Drepanidae (1)
-Image of Moths Around Light (1)
- Moths Drawn to Light (2)
-image of moth at night (1)
- image of Acheta domesticus (1)