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EFFECT OF TEMPERATURE ON MOTH ABUNDANCE AND DIVERSITY

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ABSTRACT

Moths comprise the majority of the order Lepidoptera and as a group are ecologically significant because they are pollinators for a variety of plants. Moths are sensitive to changes in temperature, and these changes can have many different effects depending on the species. Higher temperatures are documented to increase moth species diversity and abundance. This study looks at the presence of moths on a central Pennsylvanian college campus and whether it varies by temperature. We hypothesized that moth abundance and diversity would increase with temperature. We light sheeted at 54˚F and 76˚F and found much higher numbers of moths at the higher temperature. The implications of this may be important in the face of the growing climate crisis.

Keywords: Moths, Lepidoptera, temperature change, species diversity

INTRODUCTION

Moths are members of the order Lepidoptera, and in fact comprise 91% of the order with more than 135,000 species (Heppner 2008). There is much diversity in body shape and size as well as niche type among the 118 families of moths (Heppner 2008). They are ecologically important pollinators, though their importance has historically been somewhat overlooked (Walton et al 2020). They are known to be influenced by many environmental factors, including temperature and weather patterns (Holyoak et al 1997). For this study, we wanted to take a look at the species assemblages of moths that can be found on the Juniata campus, a college in central Pennsylvania, and measure how they are affected by changes in temperature.

Higher temperatures have been shown to shorten moth developmental time, alter calling times, alter sexual rhythms, hasten time of oviposition, and even decrease pheromone levels (Ashamo and Odeyemi, 2004; Webster and Conner, 1986; Thibout 1974, Blomefield and Giliomee 2011, Giebultowicz et al 1992, respectively). Moths are so sensitive to changes in temperature because they are poikilothermic, meaning their body temperature can vary considerably to match its surroundings (Choi 2008). A study done in southern Korean forests found that mean temperature was the main factor for predicting the time of moth emergence and that the temperature had significant effects on species richness and abundance (Choi 2008). A growing issue in the world of ecology is that of climate change, and many studies are being carried out to identify the ways in which climate change will affect the planet. Since moths (and other insects) are poikilothermic, they may be more vulnerable to warming climates than species that can regulate their body temperature.

METHODS AND MATERIALS

For this project, we chose a site on the Juniata campus and sampled it at two different temperatures. Each sampling lasted from half an hour before astronomical twilight began until half an hour after astronomical twilight ended (about an hour and a half in total). The site is behind Brumbaugh Academic Center by the garden and was mainly chosen for its

DOI

proximity to an electrical outlet since we needed to plug in our UV light.

We used a technique called lightsheeting, which involves hanging up a white sheet and pointing a UV light at it to attract any moths in the area. The materials we used for this project were a white bedsheet, an ultraviolet light, an extension cord, lots of little collection jars, string, and iNaturalist to aid in identifying species. While watching for moths, we periodically scanned the area in front of the sheet as well as the sheet itself, as moths would often hide in the grass. The moths that were in the vicinity but did not fly onto the sheet were counted, since our goal was to get a count of the total moths in the area. We captured the moths in collection jars for ease of identification. It is likely that not every single moth was counted because they are small and hard to capture, but we believe that it was a reasonably thorough sampling.

After the data was collected, we analyzed the results with a chi squared test on the temperature and abundance data. We then calculated Simpson's diversity index on the species data collected.

RESULTS

We found a species richness of 3 in the cold weather sample and 18 in the warm weather sample. We found a total abundance of 55 in the warm weather sample, as there were some species that we were unable to identify. The number of moths observed at different average temperatures differed significantly from the expected values ($x^2 = 29.1726$, $P > 0.00001$; see Table 1). The calculated Simpson's diversity index varied greatly between warm and cold weather samples. Simpson's diversity index was calculated at 0.9722314 for the warm weather sample, the closeness to 1 indicates that it is very highly diverse. Simpson's diversity index for the cold weather sample was 0.66667, which indicates a lower species diversity of moths in cold weather. See Table 2 for species data.

Table 1. Observed and expected frequencies of moths at different sample temperatures

Avg Temp (°F)	Observed	Expected
Cold (54)	3	29
Warm (76)	55	29

Table 2. Observed moth count and species data at each sampling data.

Species of moth	Cold 54 °F	Warm 76 °F
Athetis tarda	0	1
Xanthorhoe spadicearia	0	1
Eupithecia miserulata	0	4
Hypena scabra	0	1
Orthodes majuscula	0	2
Achatia distincta	0	2
Cleora sublunaria	0	4
Kocakina fidelis	0	1
Phoberia atomaris	0	2
Morrisonia evicta	0	1
Aphomia sociella	0	1
Sonia canadana	0	3
Perittia herrichiella	0	2
Lomographa vestaliata	0	3
Ailanthus webworm	0	1
Galgula partita	0	1
Cladara limitaria	0	1
Hydriomena renunciata	0	3
Orthosia hibisci	1	0
Nemoria bistriaria	1	0
Unidentified	1	21
Total	3	55

DISCUSSION

Unfortunately, due to the difficulties of acquiring equipment and scheduling sampling on days without rain, we were unable to sample as many times as we planned to. This led to a smaller-than-ideal sample size. A more intensive study should do more replications to verify this data's accuracy.

As we hypothesized, moth abundance and diversity were significantly correlated with temperature. Our data suggests moth abundance and diversity increase with increasing temperatures (Table 1 and 2). One factor that we were not able to account for in our data was moon phase, which has been found to be a significant factor in moth abundance; fewer moths are found in light traps when the moon is full (Yela and Holyoak 1997). During the cold weather sample, the moon was a waxing gibbous, and during the warm sample the moon was waning crescent. This moon phase difference could be impacting our data.

Our findings match with current literature which has found that temperature is a major factor in moth abundance (Choi 2008, Yela and Holyoak 1997).

This was expected, though it was surprising how significant the difference between warm and cold was. We are interested in the comparison of this research to moth population research in other areas, as well as the comparison of moth populations over time. As mentioned in the introduction, climate change is a growing issue and is already causing profound impacts on some ecosystems. Insect population declines have been a known issue for decades, and moths are experiencing severe declines in many places, especially in industrialized areas in the Northern Hemisphere (Wagner et al 2021). While tying insect population declines to climate change is outside the scope of this research, it is important to document baseline population numbers in order to make any meaningful comparisons.

In order to further clarify our findings, future studies should be done with more replicates, and in different locations around campus, as our study only took place in one location. Our data could be supported by future studies that collect data across a larger range of temperatures and weather conditions.

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