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Mosquito Population Dynamic and Risk Mitigation in High Elevation Communities & Livestock of Southern Utah, United States

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Abstract*— In areas that do not have designated mosquito management or vector control programs, there is typically limited data on potential mosquito related risks. The purpose of this project was to gather information that could be used to define the extent of mosquito related problems and the potential risk they pose to local populations, including livestock. Mosquito population data were collected at three sites using EVS CO2 baited traps, which utilize dry ice to attract female mosquitoes. The traps were set out from dusk to dawn one night each week for the duration of the active mosquito period. The number and species of mosquitoes captured were recorded along with environmental conditions. The species collected were verified by the Southwest Mosquito Abatement Laboratory in St. George, Utah. The duration of the active mosquito season lasted from May to September with the peak period in June and July. Typical activity periods were observed from dusk to dawn. Species within the Culex, Culiseta, and Ochlerotatus genera were observed. Through external lab analysis, it was determined that all mosquito samples were negative for West Nile Virus, Western Equine Encephalitis, and St. Louis Encephalitis Virus. The levels of mosquitoes observed in the collection areas were at nuisance levels in at least some of the high elevation areas studied. However, few specimens of known disease vectors (e.g. Culex tarsalis) were observed. Under these conditions, it was determined that the mosquito populations present would pose minimal disease risk to the local human and livestock populations. We would recommend nuisance management/mitigation techniques be used, including wearing protective clothing and using effective mosquito repellent, rather than employing larvicide or adulticide treatment in the area.

***Index Terms*— disease vectors, high elevation, livestock, United States.**

I. INTRODUCTION

West Nile Virus (WNV) is consistently found in mosquito populations across the state of Utah, with human and animal cases being recorded every year [15]. WNV is the leading cause of mosquito-borne disease in the continental United States [13]. With WNV spreading across the United States it is important to monitor vector populations, such as mosquitoes, that could potentially pose a risk to public health and the surrounding livestock population. In response to this safety concern, a majority of the counties in Utah have established mosquito abatement districts to monitor and, when necessary, treat mosquito populations in their area [14]. However, even though WNV cases have been identified all across the state of Utah and in neighboring counties, Iron County does not have an established mosquito abatement program. Currently, there is no monitoring of mosquito populations or diseases that they could potentially carry in the county.

Not having a mosquito abatement district to monitor mosquito populations in Iron County is concerning because of the high level of outdoor recreation in the area. Southern Utah University (SUU) is designated as the University of the Parks and consistently encourages students and community members to spend time outdoors. SUU is within a five-hour drive of more than 20 national parks and monuments in Utah, Arizona, and Nevada. The university takes advantage of this close proximity and sponsors a variety of free outdoor activities for students and faculty routinely use these public lands to connect classroom learning to real world experiences. SUU also supports outdoor activities by housing the largest federal internship program in the country and placing more than 300 students into outdoor related internships every year [12]. Outside of the university, outdoor recreation is a growing pastime and industry in Utah. From 2021 to 2022, the outdoor recreation economy in Utah grew 32.8%, the largest recorded measure for Utah since the Bureau of Economic Analysis started calculating the size of the outdoor recreation economy in 2012 [16]. In 2022, outdoor recreation constituted 3.2% of the state GDP, which is the 9th highest in the nation [9]. The three closest national parks and monuments to SUU attract almost 8 million visitors every year [5], [10], [19]. With such a large number of people enjoying outdoor recreation, those who live in Utah may be at a greater risk of contracting vector borne diseases from mosquitoes simply because of their increased time spent outdoors.

A mosquito abatement district in Iron County is also important because of the prevalence of livestock and agriculture in the area. The number of farms in the county grew 12% from 2017 to 2022, with the county also experiencing a 221% increase in net cash farm income [6]. In

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2022, Iron County was the second highest producer of sheep, goats, and related products, and the tenth highest producer of cattle and calves in the state [6]. Given the prevalence of agriculture in the county, it is important to understand the composition of the mosquito population in the area and determine how that could impact the existing agriculture. It is known that mosquitoes are a nuisance pest that impact livestock weight gain, behavior, and condition. Reference [4] found that cattle with a high level of mosquito nuisance will bunch and spend time fighting the mosquitoes instead of grazing. This can lead to weight gain reductions of 0.04 kg/day/steer. This is particularly concerning in Utah where approximately three-quarters of the landscape is uncultivated or not permanently occupied by humans, giving livestock a large area that could be used as rangeland [17]. With Utah being in the top three states in the nation with the highest mean elevations greater than 1,800m, much of the rangeland is at high elevations. Reference [4] suggests there is a crisis with declining research and extension resources addressing livestock parasite and veterinary entomology issues in the western United States. With the prevalence of livestock rangeland at high elevations in Utah, and Iron County specifically, it is important to develop baseline data sets and to monitor the population for mosquito risks.

Mosquitoes have been collected and identified in many high elevation areas across the Western United States, including Colorado, New Mexico and Arizona, and Wyoming. In the Colorado Front Range [3], identified eight mosquito species within the *Ochlerotatus* genus and two species in the *Culiseta* genus from 3,048m - 3,658m. Reference [11] conducted a study in Colorado at elevations above 2,896m and found similar results as [3], as well as different species not previously identified in the area. A further study in Colorado at elevations ranging from 3,018m - 3,627m identified a similar list of mosquito species with the majority being within the *Ochlerotatus* and *Culiseta* genera [8]. Mosquito species were also collected and identified in New Mexico and Arizona at high elevations with eight species within the *Ochlerotatus* genus and two species within the *Aedes* genus being identified [18], and at elevations ranging from 2,896m - 3,200m in Wyoming where thirteen *Ochlerotatus* species, two *Culiseta*, and fives *Aedes* species were identified [7].

The studies conducted in Colorado, New Mexico, Arizona, and Wyoming have identified many different species of mosquitoes that were collected at high elevations around 3,048m. Previous research has identified many of the same species of mosquitoes at high elevations while also identifying species that are specific to that area and may not have been identified in other studies.

The purpose of this project was to fill the knowledge gap on the mosquito population in higher elevations of Iron County by establishing a baseline of mosquito species present to provide a mosquito management plan for the area. To conduct this research, collection sites at high elevations on Cedar Mountain were chosen because of the presence of free roaming livestock and a high level of outdoor recreation that is known to occur, including hiking, camping, and off-roading. The goals of this project were to collect demographic data on the species of mosquitoes present, their activity, if WNV is present, and if a management plan should be proposed.

II. METHODS

A. Research Questions

The research questions determined for this project included the following:

1. What species of mosquitoes are present at high elevations on Cedar Mountain;
2. Are these species likely to carry diseases;
3. When are the mosquitoes active;
4. When is the peak season for mosquitoes;
5. Would the present mosquito population impact the livestock in the area; and
6. Should a mosquito management plan be created based on these data?

B. Collection Sites

For this project, there were fifteen designated collection sites chosen at high elevations on Cedar Mountain. The collection sites were evenly distributed between three main areas: Cedar Highlands (designation "CH" for trapping purposes), SUU Mountain Center (designation "MC" for trapping purposes), and Woods Ranch (designation "WR" for trapping purposes). These areas were selected based on where the local government offices would receive calls about mosquito problems from residents. Cedar Highlands is a subdivision of Cedar City, Utah located on Cedar Mountain near community-owned Greens Lake and other private ponds. CH trap locations ranged from 2,106m to 2,484m. The SUU Mountain Center property contains a log cabin owned and operated by SUU located on a 1,133-hectare ranch. There are several natural springs in the area with water seepage, creating frequent standing water. MC trap locations ranged from 2,448m to 2,456m. Woods Ranch is a recreation area open to the public on Cedar Mountain. The recreation area is situated in an aspen and pine forest designed for picnics, hikes, and fishing. A kid's pond is located in the upper section of the recreation area. WR trapping locations ranged from 2,490m to 2,518m. All traps were located near standing water with shade and wind cover and minimal public access for potential interactions with the trapping equipment.

C. Trapping Methods

Encephalitis vector surveillance (EVS) CO2 traps were utilized in this project. The CO2 evaporation from the dry ice attracts mosquitoes by mimicking the CO2 expulsion of humans and animals. EVS CO2 traps were utilized rather than other traps, such as CDC light traps, to reduce the

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potential collection of non-mosquito insect species and because of their regular use in determining whether WNV, St. Louis Encephalitis (SLE), or Western Equine Encephalitis (WEE) occurs within a localized area [2]. One trap was used per collection site, with five sites per area for a total of 15 traps. Each trap was baited with approximately one kilogram of dry ice. The traps were hung in a tree at chest height in proximity to a water source. A GPS was used to determine the exact elevation and location of the trap. The traps were set up weekly from dusk until dawn from May to September.

When the traps were collected, the nets containing mosquitoes were removed from the trap and stored in a cooler with dry ice during transport and were then stored in a freezer in the laboratory on the SUU campus until they were processed. The mosquitoes were identified using the Southwestern Utah Mosquitoes: Identification, Biology, and Distribution identification guide [1].

D. Disease Testing

Due to the numbers of mosquitoes collected and the population composition, collected specimens were separated into the following four groups of about 50 individuals per sample: *Culiseta* genus, *Culex* genus, *Ochlerotatus pullatus* species, and *Ochlerotatus increpitus* species. The PCR testing was conducted at the Southwest Mosquito Abatement Laboratory in St. George, Utah, using a magnex agpath ID magnetic bead extraction system to obtain an RNA sample. A master mix solution was then made by co-diagnostics labs with primers and a fluorescent probe. This solution was placed in an RT PCR machine for amplification and analysis of disease markers. The mosquito samples were tested for the presence of WNV, WEE, and SLE as is routinely done for samples from the local abatement districts.

III. RESULTS

Across the three areas of collection sites, there were six species of mosquito collected. These included *Culiseta inornata* (33 individuals), *Culiseta incidens* (22 individuals), *Ochlerotatus pullatus* (114 individuals), *Ochlerotatus increpitus* (693 individuals), *Culex tarsalis* (33 individuals), and *Culex erythrothorax* (8 individuals) (Fig. 1).

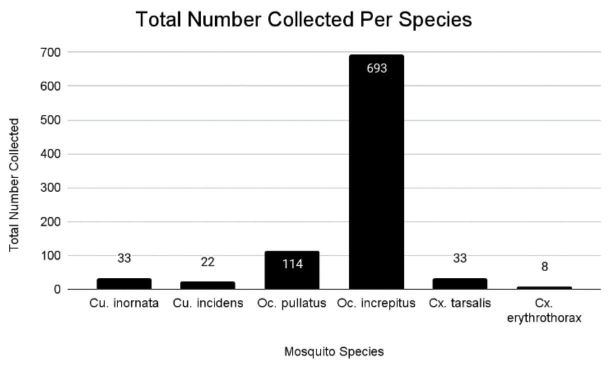

Figure 1

Fig 1. The total number of specimens collected per species during the collection period to show the mosquito population composition.

The mosquito population during this project was active from May until early September, with the peak season being in June and July (Fig. 2).

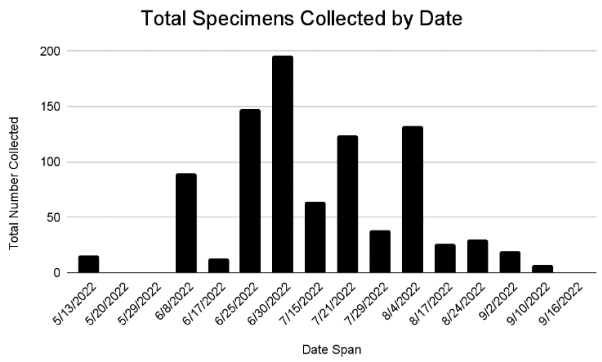

Figure 2

Fig. 2. The total number of specimens collected during the project to show the active season for the collection area.

All samples tested were negative for WNV, SLE, and WEE.

IV. CONCLUSION

The species collected within this project are similar to specimens collected in other high elevation studies. During this project, species within the *Ochlerotatus*, *Culiseta*, and *Culex* genera were collected. The majority of the species collected in the five studies previously discussed were within the *Ochlerotatus* genus, with most of them also collecting various *Culiseta* species [3], [7], [8], [11], [18]. In addition to these two genera, two previous studies also collected *Culex* species [8], [11]. While all but one previous study collected *Aedes* species, this project did not. However, that is consistent with the region historically having collected few *Aedes* species [1].

Within the species collected, there was limited potential for diseases to be present. The *Culex* genus is a known vector, with *Culex tarsalis* being one of the most prominent vectors of arboviruses in North America and *Culex erythrothorax* being highly susceptible to WNV [1]. The species within the *Ochlerotatus* genus are not known to be disease vectors and the *Culiseta* genus is considered only a moderately efficient vector with disease testing in southwest Utah historically being negative [1]. Given the negative genetic testing results and the local mosquito population demographics, namely the low number of known vectors, it is unlikely that diseases are present in the current population. However, continued monitoring is recommended as population demographics could change. Known vectors are present in the area and with diseases such as WNV being recorded in surrounding areas, there is potential for the local population to become infected.

In addition to diseases impacting the human population, there is the potential for the collected species to impact livestock in the area. The *Ochlerotatus increpitus* species is known to be a pest to cattle and humans. The *Culiseta* genus species are known as "winter" mosquitoes or "cool weather" mosquitoes and are larger than other species. As a result, they primarily feed from larger, slow moving mammals. The *Culex* genus primarily feeds on birds and small mammals and would likely not impact the livestock. With the low presence of vectors, it is unlikely that these species would impact livestock beyond being a nuisance [1]. However, it is recommended to continue monitoring mosquito populations and interaction with livestock for any changes in population composition or disease status.

The management plan recommendations for this area are for nuisance management rather than vector control. It is recommended to wear protective clothing and effective repellent when outdoors. Based on the low numbers of known vectors collected, larvicide or adulticide management methods are not recommended. It is also recommended that monitoring for population demographics and disease testing continue.

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