

Diversity of Lampyridae (Firefly) Species Across Colorado

Honors Thesis

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Abstract

Fireflies, lightning bugs, and glowworms (Coleoptera: Lampyridae) are ecologically and culturally significant, yet their diversity and distribution in Colorado remain poorly understood. This study examined 327 Lampyridae specimens from the C. P. Gillette Museum of Arthropod Diversity at Colorado State University. Specimen data, including taxonomic identification, collection locality, and date, were entered into the global Ecdysis database and mapped using geographic information system (GIS) software with county and watershed boundaries. Six genera (*Ellychnia*, *Photuris*, *Photinus*, *Pyractomena*, *Pyropyga*, and *Lucidota*) were identified, though many specimens could only be resolved to the genus level. Collections were concentrated along the Front Range, while the Western Slope, Eastern Plains, and San Luis Valley were underrepresented. Several genera, including *Ellychnia* and *Pyropyga*, likely comprise species complexes requiring further taxonomic and genetic study. Although all eleven major watersheds were represented, specimens were collected from only 36 of Colorado's 64 counties, reflecting a spatial sampling bias. These findings establish a baseline checklist of Lampyridae in Colorado, highlight significant geographic gaps, and underscore the need for targeted survey efforts to support regional conservation and management of firefly populations.

Introduction

Lightning bugs, fireflies, and glowworms are common vernacular names for beetles within the family Lampyridae. This family is culturally and ecologically significant, best known for the bioluminescent displays produced by many of its members. However, not all species within Lampyridae possess photic organs, and several are primarily diurnal, lacking any bioluminescent capability (Stanger-Hall et al., 2007). Accurate identification of lampyrid

specimens to the genus or species level presents substantial challenges due to the extensive morphological variation observed in photic organs, compound eyes, and antennal structures. Much of this morphological diversity is believed to have evolved independently and rapidly as a result of sexual selection (Martin et al., 2019).

Firefly populations worldwide are experiencing increasing conservation pressures associated with anthropogenic activities. The primary threats include habitat loss, artificial light pollution, and widespread pesticide application (Lewis et al., 2020). Since many Lampyridae species depend on moist environments in and around bodies of water for reproduction and larval development, the continued degradation and conversion of wetland habitats as a result of human expansion pose a significant risk to their long-term survival (Lewis et al., 2024). Artificial light pollution also poses serious risks for bioluminescent firefly species; artificial light can reduce the mating frequency and success of Lampyridae species that rely on the use of photic organs to attract and identify mates. Along with habitat conversion, increases in light pollution from human encroachment will dramatically impact lightning bug populations (Van den Broeck, 2021).

Although fireflies are a familiar feature of ecosystems and have been thoroughly documented in several regions of North America, the diversity and distribution of Lampyridae species in the American West remain poorly understood, particularly in Colorado (Walker et al., 2024). This lack of comprehensive data, combined with Colorado's rapid population growth, ongoing land development, and the accelerating impacts of climate change, highlights the need for a detailed and systematic checklist of the species present within the state (Walker et al.,

2024). Establishing such a baseline is essential for informing future research, conservation planning, and habitat management strategies aimed at protecting regional firefly diversity.

Methods

Specimens of Lampyridae were examined from the collections of Colorado State University's C. P. Gillette Museum of Arthropod Diversity. Data associated with each specimen, including taxonomic identification, collection locality, date, and other relevant metadata, were systematically recorded and entered into Ecdysis, a global database designed for the standardized collection and storage of arthropod specimen information. This approach ensured consistent data management and facilitated future comparative analyses of species diversity, geographic distribution, and conservation status.

Following data entry, the records were imported into a geographic information system (ArcGIS) mapping program that included the Colorado watershed and county boundaries (Colorado Department of Natural Resources). This allowed spatial visualization of specimen distributions across the state and enabled identification of patterns in collection density and regional representation. Many specimens were identified only to the genus level and lacked species-level information. These specimens were represented on the maps at the genus level (e.g., *Photuris* spp.), ensuring that all available data could be incorporated into the geographic analysis without inflating species counts.

In the mapping program, watershed and county layers were used to organize and summarize specimen records by region. Colors were applied to indicate species-level identifications and counts of specimens within each county and watershed were calculated to

provide a quantitative overview of collection coverage. This approach enabled visualization of geographic gaps in the museum’s holdings and provided a foundation for future studies on species distributions, habitat associations, and conservation priorities within Colorado.

Results

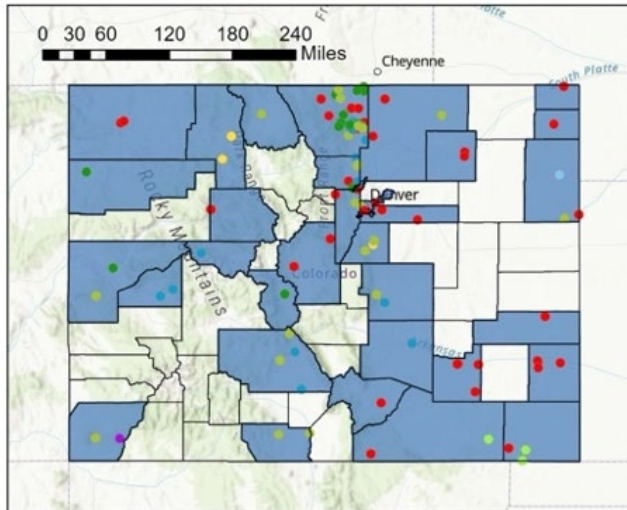


Figure 1: Map displaying all Lampyridae collection sites in Colorado, with various colors representing different species. This map also displays what counties have Lampyridae collection sites, with those in blue having

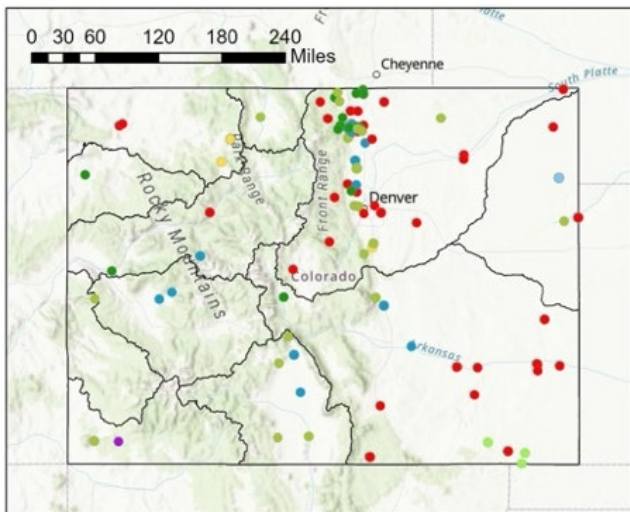


Figure 2: Map displaying all Lampyridae collection sites in Colorado, with various colors representing different species. This map also displays the eleven major watersheds in the state.

Species List

● Pyropyga	● Ellychnia
● minuta	● corrusca
● Pyropyga	● Ellychnia
● nigricans	● flavicollis
● Photuris spp.	● Pyractomena
● Photuris	● dispersa
● tremulans	● Photinus pyralis
● Ellychnia spp.	● Lucidota spp.
	● Lucidota atra

A total of 327 Lampyridae specimens

were cataloged and mapped across

Colorado. Specimens were collected from 36

of the state’s 64 counties, representing all

eleven major watershed basins. Despite this

broad hydrological coverage, most

specimens were concentrated along the

Front Range, particularly in and around Fort

Collins, Larimer County, and adjacent areas.

Figure 1 shows the counties from which

specimens were collected. Counties along

the northern Front Range and central mountainous regions had the highest collection density, with over 57% of the specimens (187) from Front Range counties and 117 of those from Larimer County alone; while large portions of the Western Slope, Eastern Plains, and San Luis Valley had few or no records. Figure 2 overlays all specimen localities on Colorado's major watershed boundaries, confirming that Lampyridae representatives were recorded from each major drainage system despite uneven sampling intensity across the state.

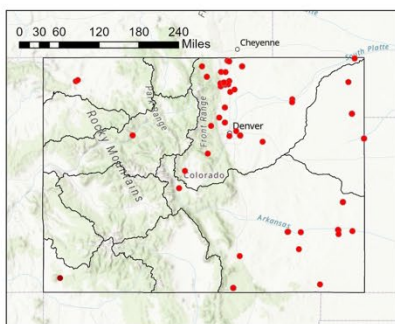


Figure 3: Map displaying all collection sites for the *Pyropyga* genus in Colorado

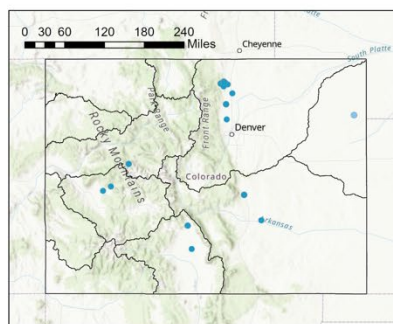


Figure 4: Map displaying all collection sites for the *Photuris* genus in Colorado

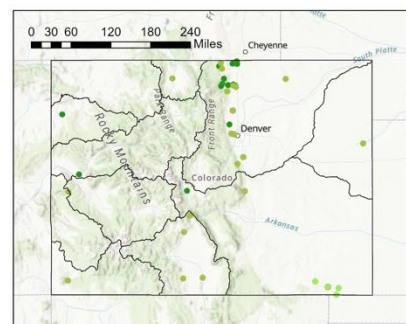


Figure 5: Map displaying all collection sites for the *Ellychnia* genus in Colorado

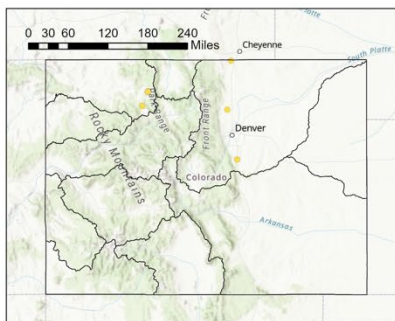


Figure 6: Map displaying all collection sites for the *Pyractomena* genus in Colorado

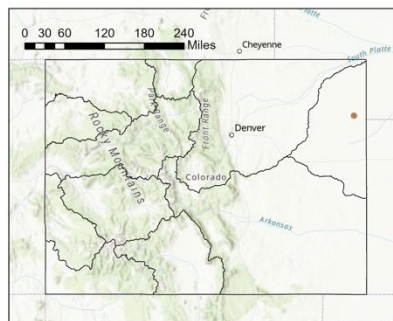


Figure 7: Map displaying all collection sites for the *Photinus* genus in Colorado

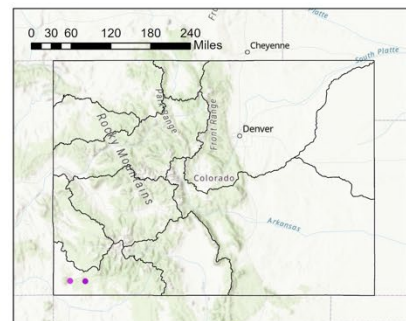


Figure 8: Map displaying all collection sites for the *Lucidota* genus in Colorado

Figures 3–8 display the spatial distributions of the six genera identified in this study:

Pyropyga, *Photuris*, *Ellychnia*, *Pyractomena*, *Photinus*, and *Lucidota*.

Figure 3: The genus *Pyropyga* was one of the most widespread groups, with specimens from *Pyropyga minuta* (red) recorded across multiple regions, though still concentrated along the

Front Range. This is contrasted with *Pyropyga nigricans* (dark red), which was collected in one location in the southwest portion of the state.

Figure 4: The genus *Photuris* (blue) was represented by a small number of specimens, primarily from northern Colorado, with some specimens from the central region of the Western Slope. *Photuris tremulans* (light blue), however, was only found in the far eastern portion of the state.

Figure 5: The genus *Ellychnia* (dark green) was the most frequently collected, showing a strong association with Front Range habitats and some representation in other regions of the state. Notably, *Ellychnia corrusca* (light green) was found in all regions of the state, with *Ellychnia flavicollis* (lime green) only found in the far southeastern corner of Colorado.

Figure 6: *Pyractomena dispersa* (yellow) occurred mainly in northern and central Colorado, but with few total specimens.

Figure 7: *Photinus pyralis* (brown) was the least represented, with limited distribution and only one collection site in the far eastern region of Colorado, in the Republican River Basin.

Figure 8: The genus *Lucidota* (purple) was also severely underrepresented, with only two collection sites in the San Juan River basin in the far southwestern corner of the state, one of which was identified as *Lucidota atra* (pink).

Discussion

A total of 327 identified and cataloged specimens were used in this study, representing six genera and at least eight distinct species. This contrasts with a previous literature study from 2023, which found seven genera and fifteen distinct species. The additional genus represented in

this review was *Microphotus*; however, the records of this genus's presence were from the early 1900's, which may make the record unreliable to current distributions (Bright and Kondratieff, 2023). The exact number of species in this study remains uncertain, as many Lampyridae specimens are often difficult to identify to the species level. Accurate identification may require observing flash patterns or conducting genetic analyses, both of which were beyond the scope of this study. In particular, the genera *Ellychnia*, *Photuris*, and *Lucidota* included several specimens that could not be confidently assigned to a specific species. In addition to these challenges, many Lampyridae species are considered species complexes, groups of genetically distinct populations that are morphologically similar and therefore difficult to distinguish. Within this dataset, *Ellychnia corrusca* and *Pyropyga minuta* are likely species complexes that require further taxonomic and genetic research to clarify species boundaries. These issues in reliably identifying specimens to a species level may also account for the discrepancies in species numbers between this study and the previous literature review (Bright and Kondratieff, 2023).

All eleven major watersheds in Colorado were represented in this study; however, specimens were collected from only 36 of the state's 64 counties. A large portion of these specimens were collected by entomology students at Colorado State University, resulting in a sampling bias toward the Front Range region, particularly around Fort Collins. In contrast, relatively few specimens were collected from the Western Slope, the Eastern Plains, and the San Luis Valley. Sampling bias was tested using a Chi-Square test, which involved calculating the expected number of specimens collected from each county and comparing it to the actual number of specimens from each county. This Chi-Square test generated a p-value of $2.2e-16$ (< 0.001). This means that there is a significant difference between the observed and the expected number

of specimens, which suggests there is a major sampling bias occurring. To develop a more complete understanding of Lampyridae diversity and distribution in Colorado, future survey efforts should focus on these underrepresented regions. Expanding geographic sampling will help build a more comprehensive species list and provide a clearer picture of firefly diversity across the state. Additionally, many of the specimens collected outside of the Front Range originated from the same limited locations, suggesting that even within underrepresented regions, sampling coverage remains narrow. Broader and more systematic collection efforts in these areas are essential to fully document the diversity of this family in Colorado.

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