

**FIREFLY SPECIES FACT SHEET:**  
**Keel-necked firefly (*Pyractomena ecostata*)**



*A keel-necked firefly from Edwin B. Forsythe National Wildlife Refuge, New Jersey (Richard Joyce/Xerces Society).*

**March 2024**  
**Updated May 2024**

**Richard Joyce**  
**Xerces Society for Invertebrate Conservation**



**Scientific Name:**

*Pyractomena ecostata* LeConte, 1878

Phylum: Arthropoda

Class: Insecta

Order: Coleoptera

Family: Lampyridae

Subfamily: Lampyrinae

Tribe: Cratomorphini

(ITIS 2023)

Synonyms: *Photinus ecostatus* LeConte, 1878

**Common Name:**

Keel-necked firefly

**Taxonomic Note:**

The specific epithet “ecostata” means having no ribs. LeConte described the type specimen as lacking elevated lines on the elytra (1878), but subtle elytral costae are present in at least some specimens.

**Conservation Status:**

Global Status: G3- Vulnerable

National Status (United States): NNR

State Status: SNR (AL, DE, FL, NJ)

(Heckscher and Walker 2021b)

IUCN Red List: Endangered (Heckscher and Walker 2021a)

Species of Greatest Conservation Need (Tier 2): Delaware (2015)

### Technical Description:

Adult: *Pyractomena* can be distinguished from other flashing firefly genera in North America (*Photinus*, *Photuris*, *Micronaspis*, *Aspisoma*) by their roughly pentagonal-shaped pronotum which features a raised keel down the midline (Figure 1). The body posture in *Pyractomena* is flat, unlike the hunched posture of *Photuris* fireflies. In female *Pyractomena*, the light organs are limited to the outer hind corners of the abdominal segments (Figure 2). The male lanterns each have two punctures called stigmatiform pores (Figure 3).

First described by LeConte (1878), *Pyractomena ecostata* is a relatively large firefly, ranging in length from 11.6-16 mm (Green 1957). It has an elongated and narrow form. The **diagonal yellow stripes on the elytra are a distinctive and diagnostic trait** (Figures 1 and 4). The antennae are noticeably short.

Examining the aedeagus (male genitalia) is not necessary for identification of specimens of this species, but *Pyractomena ecostata* is in the “*Pyractomena lucifera* Group” of North American *Pyractomena*, in which the inner margins of the lateral lobes of the aedeagus are “strongly diverging and sinuate distally” with “apices much narrowed” (Green 1957).



Figure 1. Holotype specimen of *Pyractomena ecostata*, collected on Key West, Monroe County Florida, on 29 January 1869 and housed at the Harvard Museum of Comparative Zoology. [Copyright © 2005 President and Fellows of Harvard College, Some Rights Reserved Creative Commons Attribution Share Alike Non Commercial \(CC-BY-NC-SA 4.0\).](#)



Figure 2. Ventral view of the holotype specimen. The four triangular lanterns are typical for female *Pyractomena*. [Copyright © 2005 President and Fellows of Harvard College, Some Rights Reserved Creative Commons Attribution Share Alike Non Commercial \(CC-BY-NC-SA 4.0\)](#)



Figure 3. Close-up view of the lanterns (light organs) of a male *Pyractomena ecostata* in New Jersey. Note the large size of the lanterns in relation to the other ventral segments and the presence of two pores known as stigmatiform pits on each of the lanterns. (Richard Joyce/Xerces Society).



Figure 4. A male *Pyractomena ecostata*. Note the narrow form, the raised line (keel) on the middle of the pronotum, and the yellow diagonal stripes (elytral vittae) on the wing covers. (Richard Joyce/Xerces Society)

Larva: The larval stage of *Pyractomena ecostata* was described by Wenzel (1896) and later by Green (1957). Late instar individuals can be larger than adults: 19 mm long and 5 mm. The overall coloration is yellowish, with two dark brown stripes on either side of the midline that approach each other at the front and rear ends (Figure 5). The surface of the dorsal segment is textured with wide shallow punctures (Wenzel 1896). Two small round light organs are visible on the posterior ventral segment and emit a yellowish green light (Figure 6).



Figure 5. Larva of *Pyractomena ecostata* found in Atlantic County, New Jersey on 12 July 2023 (Richard Joyce/Xerces Society).

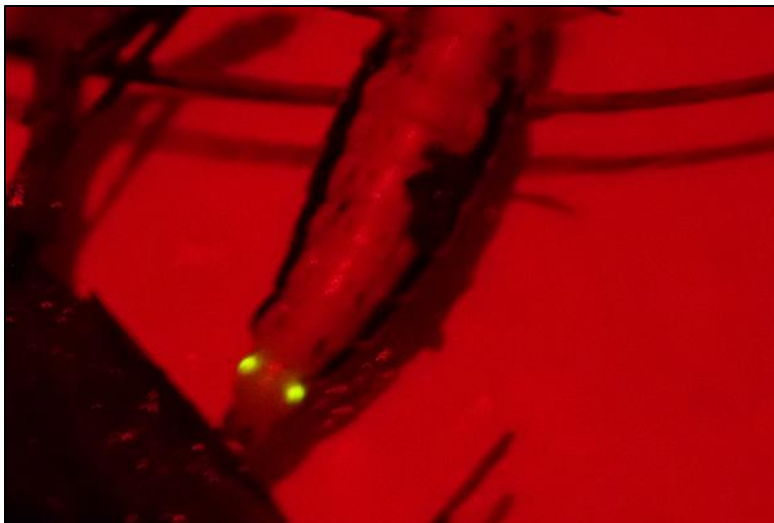


Figure 6. Ventral view of a *Pyractomena ecostata* larva photographed under red light. Note the yellowish green light emitted from two small lanterns toward the posterior end of the body.

## Life History:

### *Flash Behavior*

The male courtship flash pattern of *Pyractomena ecostata* consists of long flashes or short glows with durations of approximately 0.5-1 seconds that are emitted at relatively long intervals. (See Figures 7 and 8). The dark period or “pause” can be as long as 9-20 seconds (Lloyd 2018), but flash pattern period measured in New Jersey at 74°F was about 6 seconds (Joyce 2023). The greenish yellow flashes are remarkably bright, described as “brilliant, explosive [and] ‘firecracker’-like” (Heckscher and Lloyd 2015). The height at which males flash varies, but is often at least two meters (six feet) above the ground (R. Joyce pers obs., Lloyd 2018). Lloyd described the diversity of flash appearances as including “J-upward-swoops like those of *Photinus pyralis*, horizontal dashes, upward slants, or as sparks blown in the wind.” (2018).

Males begin flashing 30-60 minutes after sunset and continue displaying for multiple hours.



Figure 7. Composite long-exposure image of male *Pyractomena ecostata* courtship flashes taken at Edwin B. Forsythe NWR in Atlantic County, New Jersey. The image created at 9:12 PM, 47 minutes after sunset (air temperature =78° F), on 12 July 2023 and is made up of 32 4-second exposures (2 minutes and 8 seconds total). (Richard Joyce/Xerces Society).



Figure 8. Composite long exposure image of *Pyractomena ecostata* flashes over a salt marsh in New Jersey. The image was created at 11:13 PM, 167 minutes after sunset, on 11 July 2023 and is made up of 11 15-second exposures (2 minutes and 45 seconds total). (Richard Joyce/Xerces Society).

## Phenology

In Florida, adult *Pyraclomena ecostata* can be found year-round in the southern part of the state and from February to September, with an apparent peak in April, in the northern part of the state (Lloyd 2018).

In the Mid-Atlantic, adult *Pyraclomena ecostata* have been documented from mid-June to early August. The earliest season record is from 14 June 1992 at Sea Isle City, New Jersey, and the latest season record is 3 August 1972 at Woodland Beach, Delaware (Heckscher and Lloyd 2015, Figure 9).

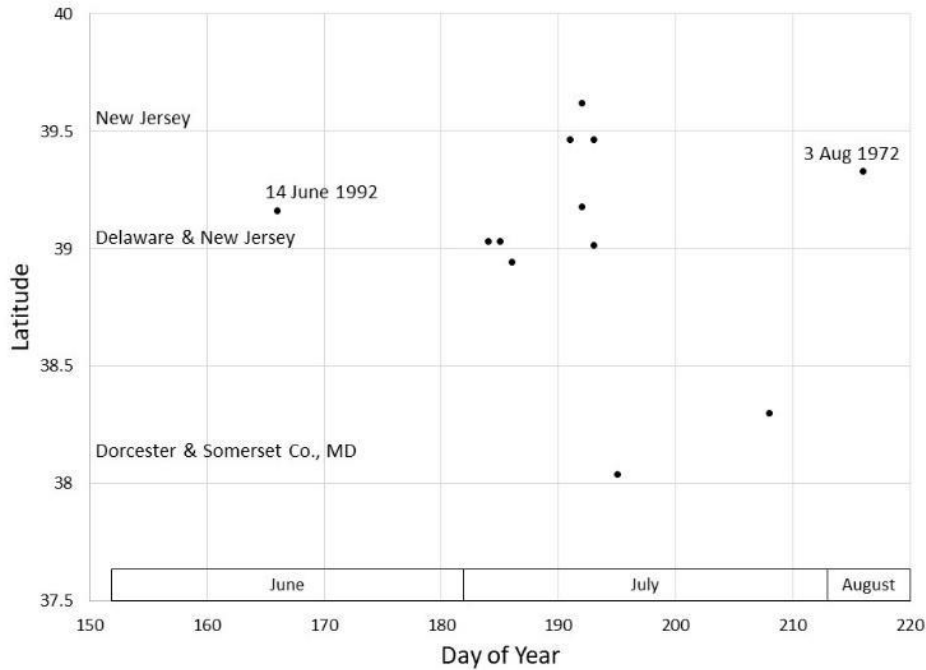


Figure 9. Phenology of *Pyraclomena ecostata* in the Mid-Atlantic region, showing records by day of year and latitude. The range of day of year records is 166-216 (14 June to 3 August).

Modified growing degree days (mGDD) are a measure of heat accumulation on a given date and over the course of the growing season, and are used to take seasonal and geographic variation into account when making phenology timing predictions and characterizations. In general, mGDD values of under 1000 correspond to the spring season, while values between 1000 and 1800 are early summer and values above this are summer into early autumn (Faust 2017). The accumulated mGDD values for *Pyraclomena ecostata* occurrence records range from 597 to 2,368, with most records falling between 1200 and 2000 modified growing degree days (Figure 10).

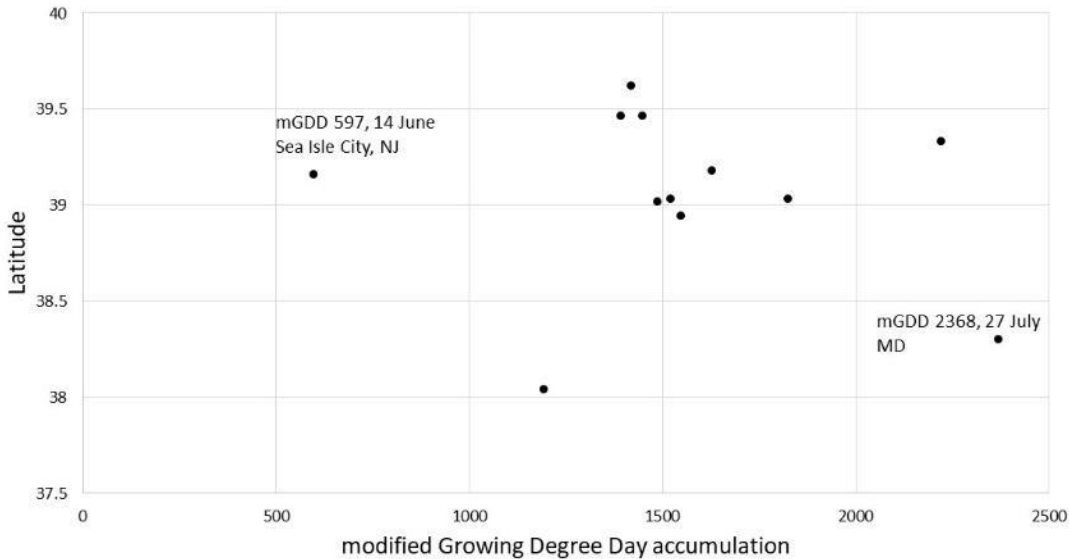


Figure 10. Phenology of *Pyractomena ecostata* in the Mid-Atlantic region, showing records by modified growing degree day accumulation and latitude. The mGDD range is 597 to 2368, with most records between 1200 and 2000.

### Dispersal capacity

The dispersal capacity of the keel-necked firefly is unknown. Fireflies are generally weak fliers and rarely disperse beyond the habitat in which they were born (Lewis 2016), though *Photinus signaticollis* was found to expand its range by 10 km/year, suggesting that some species in some habitats have larger dispersal capacities (Koken et al. 2022). The observation of a keel-necked firefly individual on the beach at Surf City, New Jersey (about 1.4 km from the closest salt marsh habitat) suggests that this species is capable of flying or being carried by the wind for moderate distances (Cricket 2022).

### Life cycle

Like all beetles, keel-necked firefly has a holometabolous life cycle, meaning it goes through four life stages: egg, larva, pupa, and adult.

The eggs of *Pyractomena ecostata* have not been observed or described, but females of other *Pyractomena* species have been observed to lay each lay about 100 eggs, laid in multiple clusters, each with progressively fewer eggs (Archangelsky and Branham 1998; Buschman 1984). Firefly eggs are faintly bioluminescent, but are difficult to detect in the wild (Faust 2017). The length of the egg phase is not known for *P. ecostata*, but *Pyractomena borealis* eggs kept in captivity hatched after one month (Archangelsky and Branham 1998).

Larvae of species in the genus *Pyractomena* are known to be specialist predators of snails, with their tapering pronota allowing them to reach inside snail shells to inject a neurotoxin. At a saltmarsh in New Jersey, the two *Pyractomena ecostata* larvae found were in the dead thatch of salt hay (*Sporobolus pumilis*, formerly *Spartina patens*) (Joyce et al. pers. obs, Figure 11). Larvae seem to glow in response to physical disturbance; both New Jersey individuals were detected close to the feet of observers.

While possible aquatic behavior of *Pyractomena ecostata* has not been investigated, the larvae of *Pyractomena lucifera* have been known to actively hunt snails underwater in freshwater and were able



to survive being submerged in water for 31 days (Buschman 1977, 1984). Thus, it is likely that *Pyractomena ecostata* has a high tolerance for tidal inundation.



Figure 11. A *Pyractomena ecostata* larva crawls through *Sporobolus pumilis* (formerly *Spartina patens*) near an empty shell of a snail in the genus *Melampus*. (Richard Joyce/Xerces Society).

The pupal stage of *Pyractomena ecostata*, has not been described, but insights can be gleaned from other species in the genus. During a prepupal phase that lasts several days, *Pyractomena* larvae decrease their activity level and adhere themselves to the substrate (often tree bark or other vegetation) (Buschman 1977; Faust 2017). Pupation of captive *Pyractomena lucifera* and *P. borealis* lasted 6-7 days and 4-5 days, respectively (Archangelsky and Branham 1998; Buschman 1977).

**Range, Distribution, and Abundance:**

Type locality: USA: Monroe Co., Key West (Harvard University and Morris 2023)

Range: The keel-necked firefly has a disjunct range, occurring in Alabama, Florida, Maryland (Reb 2023), Delaware, and New Jersey, primarily near the coast but also in some wet, herbaceous inland habitats (Heckscher and Lloyd 2015; Lloyd 2018)

Distribution:

*Documented*

As of 2023, it has been recorded in the following public lands:

Site	State	Managing entity
St. Joseph Bay State Buffer Preserve	Florida	Florida Department of Environmental Protection
Cedar Key Scrub State Reserve	Florida	Florida Department of Environmental Protection
Curry Hammock State Park	Florida	Florida Department of Environmental Protection

Merritt Island National Wildlife Refuge	Florida	US Fish and Wildlife Service
Everglades National Park	Florida	National Park Service
Edwin B. Forsythe National Wildlife Refuge	New Jersey	US Fish and Wildlife Service
Great Bay Boulevard Wildlife Management Area	New Jersey	New Jersey Fish and Wildlife
Dennis Creek Wildlife Management Area	New Jersey	New Jersey Fish and Wildlife
Fishing Bay Wildlife Management Area	Maryland	Maryland Department of Natural Resources
Deal Island Wildlife Management Area	Maryland	Maryland Department of Natural Resources
Mispillion Marine Reserve	Delaware	Delaware Natural Resources and Environmental Control

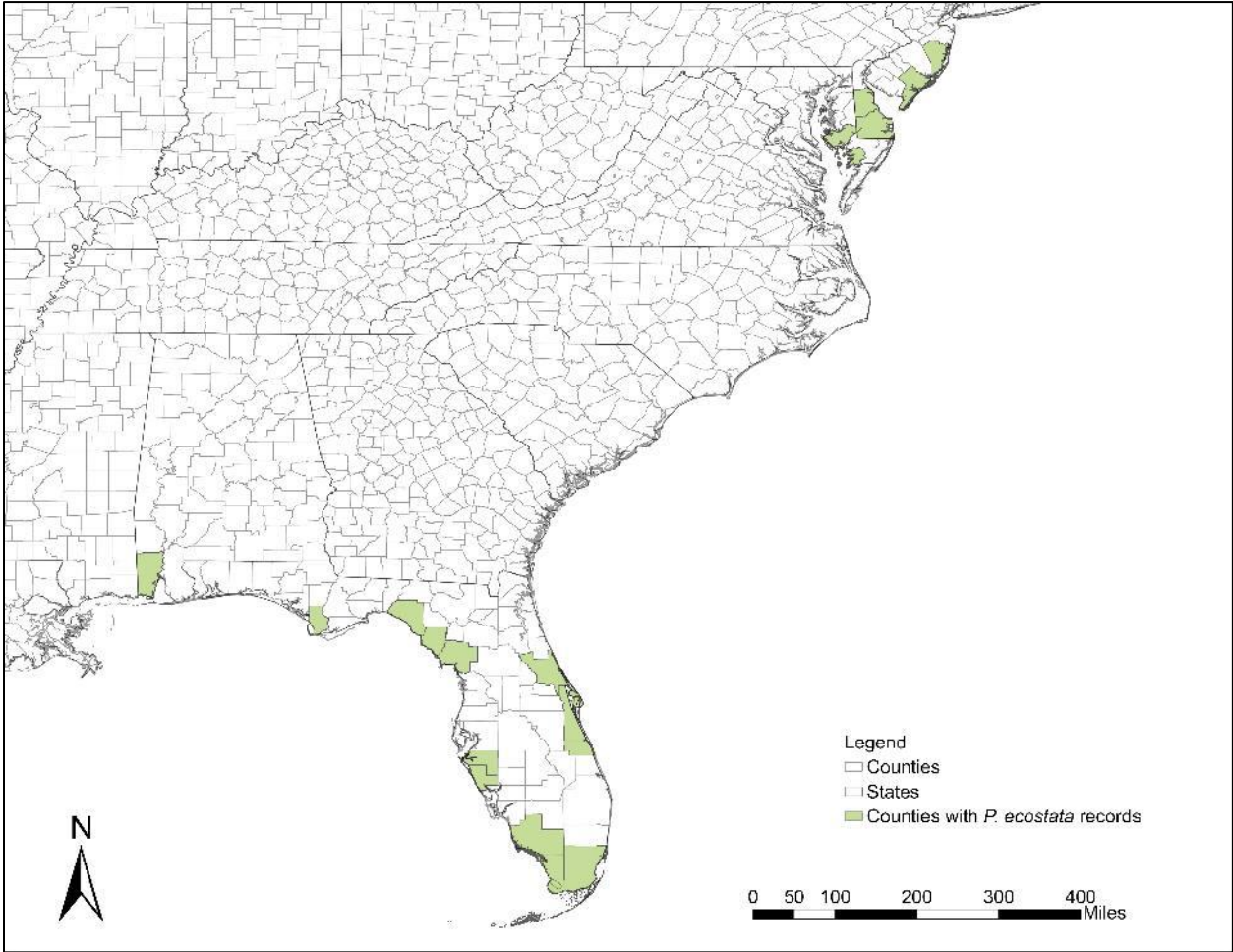


Figure 12. Distribution of *Pyractomena ecostata* at the county level as of 2024 based on literature, specimens, and observations.

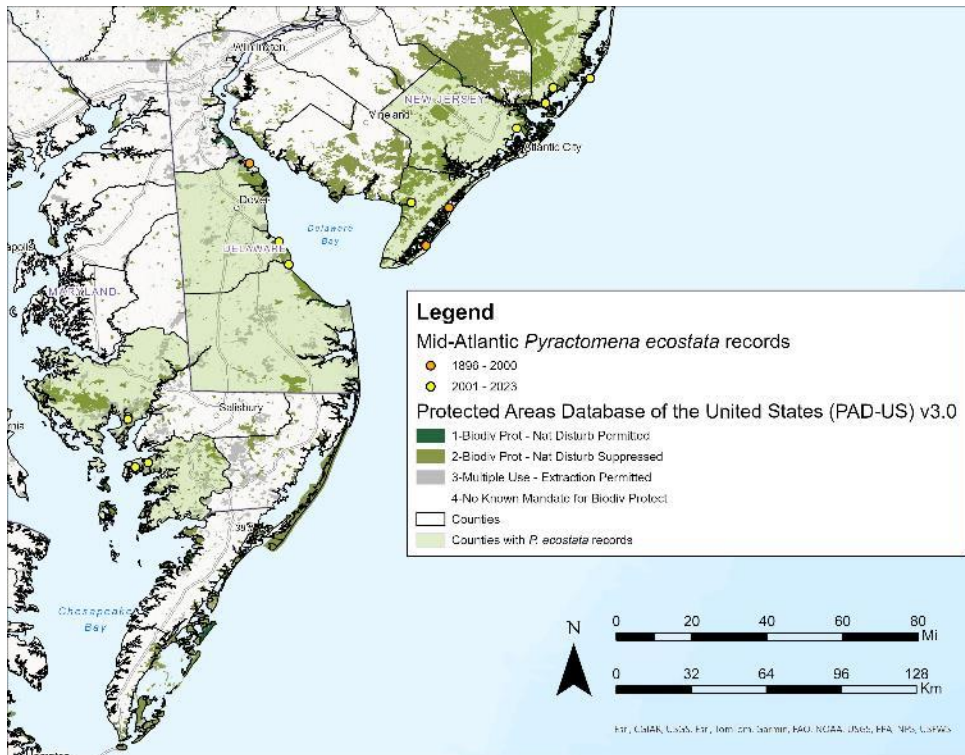


Figure 13. Counties and locations where *Pyractomena ecostata* have been documented in the Mid-Atlantic region. Counties with *P. ecostata* records are shaded light green. Point records from 2000 or earlier are orange while those from 2001 or later are yellow.

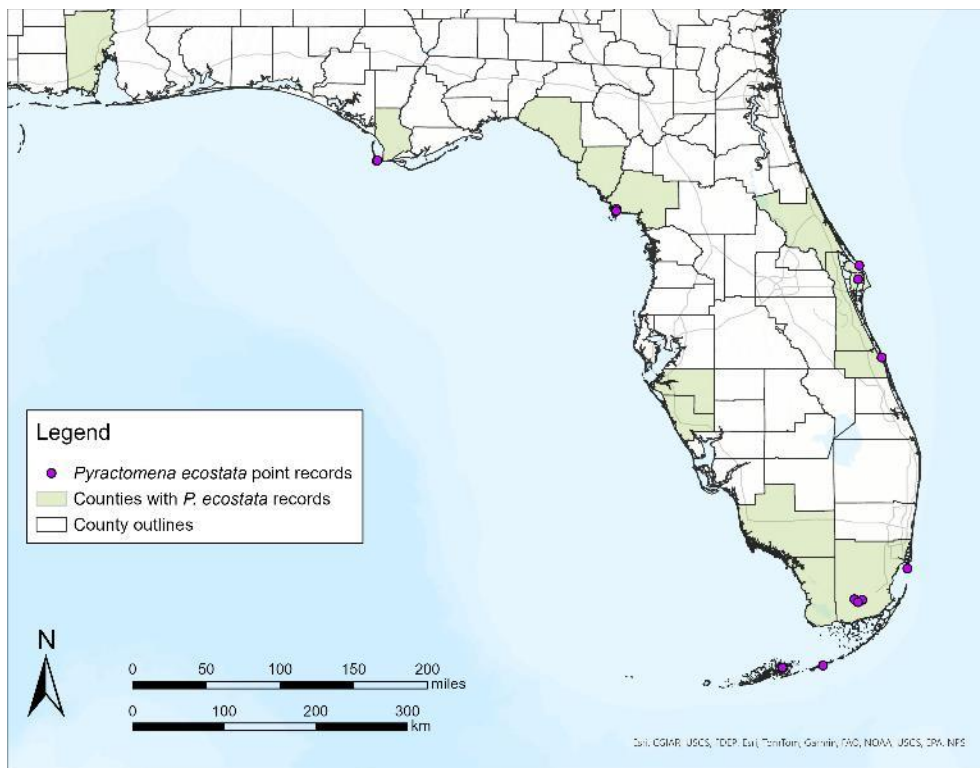


Figure 14. The known distribution of *Pyractomena ecostata* in Florida and Alabama as of 2024. Point locations are shown with purple dots, while counties with historic or current presence are shown in light green.

### *Suspected and Possible Distribution:*

It is possible that *Pyractomena ecostata* also occurs in the expanse between its two known ranges, in Virginia, North Carolina, South Carolina, and Georgia, especially given that it remained undetected in Maryland until 2023.

There are numerous national wildlife refuges, state wildlife management areas, state parks, county properties, and other public lands in Alabama, Florida, Maryland, Delaware, and New Jersey that have coastal wetlands or open freshwater marsh habitats that might support *Pyractomena ecostata* populations but have not been surveyed.

**Abundance:** Detailed data on abundance are not available. Lloyd (2018) described the species occurring “in abundance” at inland grassy sites but also recounted observations of solitary individuals. Heckscher and Lloyd (2015) surmised that the species occurs at “low numbers” in New Jersey and Delaware. Stationary Firefly Atlas surveys in Delaware in early July 2022 and in New Jersey in mid-July 2023 found totals of fewer than 50 displaying males per site.

### **Habitat Associations**

*Pyractomena ecostata* is a wetland habitat specialist found in intertidal salt marshes, mangrove swamps, and herbaceous freshwater wetlands (Figure 15).

Intertidal brackish salt marshes are generally dominated by *Sporobolus* grasses (formerly *Spartina*). In the Mid-Atlantic, *Pyractomena ecostata* adults have been found displaying over both short-form saltmarsh cordgrass (*Sporobolus alterniflorus*) and salt hay (*Sporobolus pumilus*). In Florida, salt marshes are sometimes dominated by black needlerush (*Juncus roemerianus*).

In Florida, non-tidal habitats used by *Pyractomena ecostata* include freshwater marl prairie in the Florida Everglades (MDO 2020), wet herbaceous areas bordered by scrub (Gaudette 2023), grassy roadsides, and low wet pastures (Lloyd 2018).

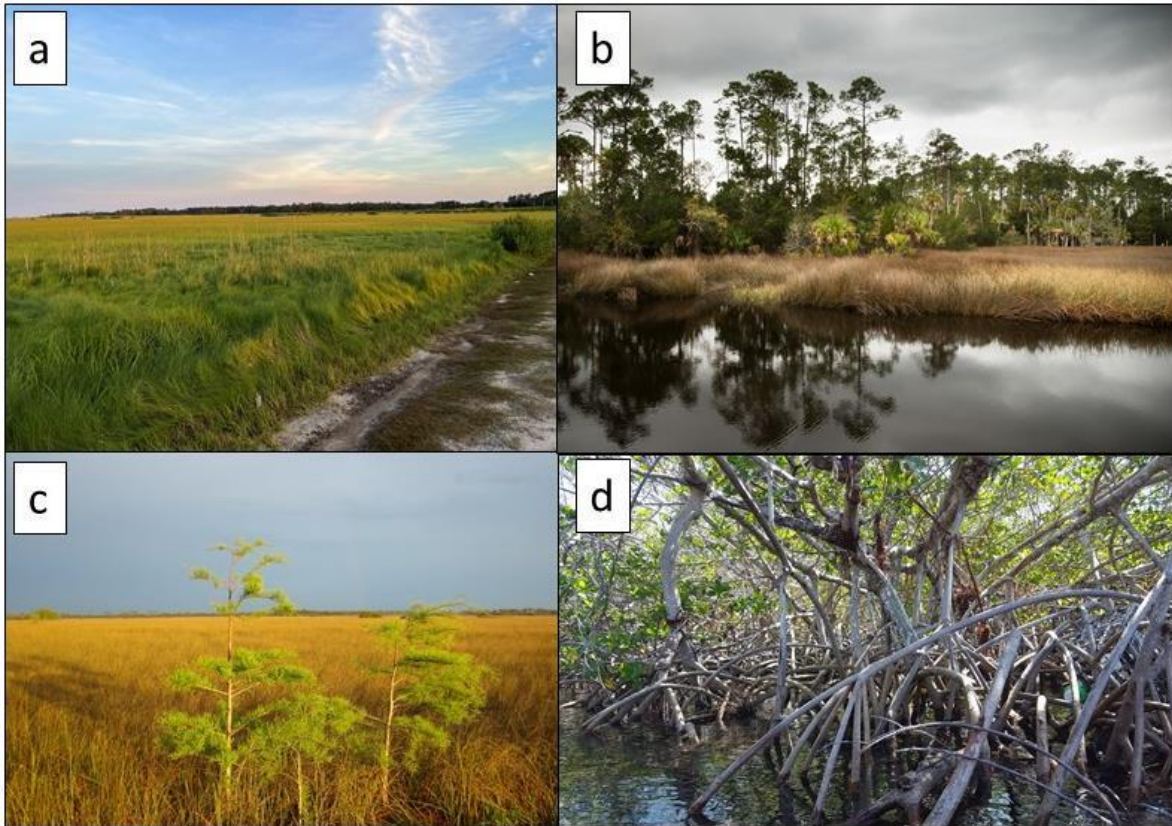


Figure 15. The keel necked firefly can be found in coastal and near-coastal wetlands, including salt marsh, brackish black needle rush marsh, freshwater marsh, and mangroves. (a) High salt marsh habitat in Kent County, Delaware (Richard Joyce). (b) Black needle rush marsh in Florida (Justin Meissen, Flickr, CC BY-SA). (c) Freshwater marl prairie in Everglades National Park (Anita Gould, Flickr, CC BY-NC). (d) Red mangroves in the Florida Keys (Jenni Konrad, Flickr, CC BY-NC).

### Co-occurring firefly species

In the Mid-Atlantic region, *Pyractomena ecostata* overlaps in display season and habitat with the salt marsh firefly (*Photuris salina*). Nearby upland habitats may also species such as *Photinus pyralis*, *Photuris hebes*, and *Photuris lucicrescens*. In coastal habitats of Florida and Alabama, the Florida intertidal firefly (*Micronaspis floridana*) and Dixon's striped firefly (*Aspisoma ignitum*) may be co-occurring species.

## Threats:

Threats to *Pyrrhopyga ecostata* include habitat destruction and degradation from development, sea level rise, invasive plants such as *Phragmites australis*, pesticide exposure, and artificial light at night (Heckscher and Walker 2021a).

Global sea level rise occurring increasingly rapidly (Hayhoe et al. 2018). The 2022 NOAA sea level rise projections estimate that the relative sea level rise from 2005-2060 will be 0.55 meters (21.7 inches) for Virginia Key in southeast Florida and 0.7 meters (27.6 inches) for St. Petersburg on the west coast of Florida (Sweet et al. 2022). Because the keel-necked firefly's habitat consists largely of upper intertidal areas during its larval stage (and presumably egg and pupal stages), even modest amounts of sea level rise will permanently flood the lower elevations of the areas that it currently occupies, likely resulting in a significant loss of this firefly's habitat.

While it may be possible for some coastal wetlands to persist despite sea level rise through vertical accretion and horizontal migration, the ability of mangroves and salt marshes to migrate and adapt to rising sea levels is greatly constrained by coastal development and infrastructure (Osland et al. 2022). Furthermore, coastal wetland migration is not a given: the collapse of freshwater wetland peat soils and accretion rates that do not keep pace with sea level rise are two factors that could lead to wetlands being submerged rather than migrating or transitioning from freshwater or brackish to saline (Chambers, Steinmuller, and Breithaupt 2019; Parkinson and Wdowinski 2022).

There is significant potential for coastal wetlands to migrate in the Everglades of South Florida and the Big Bend area of the Gulf Coast, where mangroves and salt marshes are buffered by large expanses of freshwater wetlands and upland forest (Osland et al. 2022; Raabe and Stumpf 2016). However, the coastline of Florida is extensively armored, including approximately 3,600 miles of reinforced and pre-stressed concrete seawall (Nolan, Rossini, and Nanni 2018), and demand for seawalls will likely increase with rising sea levels (Pabon 2019). In general, highly developed counties on the Florida Peninsula are poorly buffered and increasingly armored, thus presenting barriers to migration of existing marshes and mangroves.

Pesticides pose a threat to fireflies generally through lethal and sublethal effects resulting from various exposure routes: aerial spraying, contaminated soil, runoff in waterways, and consumption of contaminated prey. Pesticide uses that are of particular concern for *Pyrrhopyga ecostata* include aerial and ground-level spraying of mosquito adulticides (often pyrethroids or the organophosphate naled), which are applied in large quantities in Florida.

Artificial light at night (ALAN, also known as light pollution) has been shown to have wide range of negative effects on insects generally (Owens et al. 2020) and fireflies specifically (Owens et al. 2022; Owens and Lewis 2022), causing interference with courtship communication and lowering reproductive success. Because the keel-necked firefly begins its courtship displays 30-60 minutes after sunset (once it is dark), artificial light can interfere with its behavior. Even the illumination from a full moon can reduce firefly activity (Faust 2017), and artificial light can far exceed this level. Figure 16 illustrates the influence of coastal ALAN on *Pyrrhopyga ecostata* habitat in New Jersey.



Figure 16. Outdoor lighting from coastal infrastructure in New Jersey creates glare in *Pyrractomena ecostata* salt marsh habitat. (Richard Joyce/Xerces Society).

### **Conservation Considerations:**

#### *Research needs*

Despite recent work to assess the keel-necked firefly's conservation status and compile a comprehensive database of known occurrence records, our understanding of this species' distribution, abundance, and population trends is incomplete or lacking, which hinders our ability to effectively conserve the species. Details regarding this firefly's life history, microhabitat requirements, and vulnerability to various threats are also largely unknown, further impeding conservation efforts. There remain critical data gaps that must be addressed to inform conservation efforts for the mysterious lantern firefly, including:

#### *Natural history*

- What is the larval diet? Are certain snail species particularly important as prey? Both feeding trials with captive larvae and careful field observations could be useful to answer this question.
- What microhabitat features are important to adults? To the larvae?

#### *Species range and distribution*

- What is the full extent of this species' range?
- Is the distribution truly discontinuous, with a gap in occurrence between Maryland and Florida?
- What can species distribution modeling tell us about focusing future survey efforts?
- Can we use occupancy modeling to determine the survey- and site-level variables that influence the detection and presence of fireflies at known sites?
- What is the dispersal capacity of this species?

### *Population size, trends, and abundance*

- What are the global and local population sizes and trends for this species?
- What monitoring protocols and/or programs do we need to develop to answer this question?
- What is the most reliable index of abundance for this species?
- What is the geographic pattern of genetic differentiation?

### *Threats*

- To what extent do known threats impact the species?
- Can we model the impacts of sea level rise and other climate change impacts on their populations? What about the impacts of increasing development and light pollution?

### *Conservation impacts*

- How do different management activities impact adult firefly populations?
- How do different management activities impact immature firefly populations?
- How can we use this information to guide conservation and restoration activities?

### *Inventory and monitoring*

In addition to addressing data gaps, continued surveys of coastal wetlands are needed to determine the full extent of this species' range. This firefly may occur in appropriate habitat elsewhere in Delaware and Maryland, as well as New Jersey, eastern Virginia, and eastern North Carolina. Coordinating with researchers targeting other nocturnal coastal taxa (such as black rail) could increase the survey effort for *Pyractomena ecostata*.

As core sites for this species are discovered, land managers could work to establish long-term monitoring programs to better understand population size, dynamics, and trends.

### *Management actions*

Land managers can play a key role in ensuring that known and potential habitat of keel-necked fireflies is not disturbed by recreation, development, harmful pesticide applications, light pollution, or other management activities. Key actions that could help this firefly include:

- establishing and maintaining natural buffers around intertidal wetlands to maintain hydrology, protect groundwater, and reduce stormwater, pollution, and nutrient run-off
- rerouting roads and trails around sensitive habitat areas
- installing boardwalks or bridges if passage through the site is required
- removing or modifying artificial light sources such as streetlights that may be negatively impacting populations (e.g., using motion sensors on existing lights, or replacing bright LEDs with dim red bulbs that don't interfere with firefly flash communication; see Figure 17)
- protecting occupied sites from excessive or unnecessary pesticide application



- removing invasive plants such as the common reed *Phragmites australis*, which may alter native plant communities and make them uninhabitable for fireflies
- restoring natural hydrology by removing impoundments and ditches
- setting up long-term monitoring programs at a subset of occupied sites to gather baseline population data to better understand population trends and conservation status of this species over time, as well as insights into the impacts that various management activities have on firefly health and abundance.



Figure 17. Red lighting at a national park campground preserves dark skies and minimizes impacts on insects and other wildlife. (Richard Joyce / Xerces Society).

## Survey Protocol:

### When:

- *Southeast region:* Year year-round, when temperatures are at least 68° Fahrenheit (20° Celsius)
- *Mid-Atlantic region:* Mid-June to early August, between 1200 and 2000 modified Growing Degree Days (mGDD).
- Surveys should begin at sunset.
- Beaufort wind scale should be Force 2 or lower (0-7 mph).
- Moon phase should ideally be last quarter, waning crescent, new moon, or waxing crescent.

### Where:

- *Southeast region* (Florida, Alabama): Mangrove swamps, salt marshes, black needle-rush marsh, freshwater marl prairie, and wet grassy roadsides.
- *Mid-Atlantic region:* Salt marshes and wet grassy swales.

### How:

- Review survey protocols and print data sheets from the Firefly Atlas ( [www.fireflyatlas.org](http://www.fireflyatlas.org) )
- If needed, secure the appropriate permits and/or site access permissions prior to conducting surveys.
- Walk slowly along or through intertidal habitats or wet, herbaceous freshwater wetlands looking for flashes and glows.
- Consider recording observation data using a voice memo app or a voice recorder, using the data sheet as a guide.
- Use artificial light sparingly to maintain your night vision and avoid disturbing fireflies; a dim red headlamp or a flashlight wrapped in red cellophane can be used as needed to navigate the site.
- Photograph any glowing larvae encountered.
- If permitted, net several individuals and take high quality dorsal and ventral photos, including a scale to show the length of the firefly. Photos will enable validation of species identification by a Firefly Atlas administrator or relevant species expert.
- Submit survey data and photographs to the Firefly Atlas (including from surveys where fireflies were not detected).

## **Additional Resources:**

### *Species-specific*

- 'Wanted' Poster: Have you seen this rare firefly? <https://www.fireflyatlas.org/firefly-posters>

### *Firefly Conservation*

- Conserving the Jewels of the Night: Firefly-Friendly Lighting Practices (<https://xerces.org/publications/fact-sheets/firefly-friendly-lighting>)
- Conserving the Jewels of the Night: Guidelines for Protecting Fireflies in the United States and Canada (<https://xerces.org/publications/guidelines/conserving-jewels-of-night>)
- State of the Fireflies of the United States and Canada: Distributions, Threats, and Conservation Recommendations (<https://xerces.org/publications/scientific-reports/state-of-fireflies-of-united-states-and-canada>)

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