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CITIZEN SCIENCE

PEARLY-EYE BUTTERFLIES (LEPIDOPTERA: NYMPHALIDAE) OF COLONIAL NATIONAL HISTORICAL PARK, VIRGINIA

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ABSTRACT

During an August 2016 butterfly survey conducted in Colonial National Historical Park, VA, a single Creole Pearly-eye (*Enodia creola*) and 12 Northern Pearly-eyes (*E. anthedon*) were documented in an area of the park known as Neck of Land. During a second butterfly survey conducted in the same area one year later, two more Creoles and three Northern Pearly-eyes were documented. Finding Creole Pearly-eye butterflies represented a new record for James City County and with permission from the National Park Service, a study of pearly-eye butterflies in the Neck of Land area was conducted during 2018–2019. Pearly-eye numbers, distribution, caterpillar feeding, and timing of broods were documented. During the study, three Southern Pearly-eye butterflies (*E. portlandia*) also were documented, representing another new James City County record. Ranges for both the Creole and Southern Pearly-eye butterflies appear to have extended northward along the Atlantic Seaboard.

Keywords: Creole Pearly-eye, *Enodia creola*, Northern Pearly-eye, *Enodia anthedon*, Southern Pearly-eye, *Enodia portlandia*, Satyrinae, Switch Cane, *Arundinaria tecta*, Japanese Stiltgrass, *Microstegium vimineum*, Neck of Land, Jamestown Island, James City County, county record.

INTRODUCTION

Pearly-eyes belong to a group of butterflies known as satyrs (Lepidoptera: Nymphalidae: Satyrinae). There are estimated to be over 2,400 species of satyrs found world-wide, including almost 50 species in the United States (US) and Canada. Fifteen species of satyrs are found in the eastern US, three of which are sibling species called pearly-eyes: the Northern Pearly-eye (*Enodia anthedon*), the Southern Pearly-eye (*E. portlandia*), and the Creole Pearly-eye (*E. creola*). Butterfly names used herein are based on Cassie et al. (2001).

These three satyrs are categorized as woodland satyrs because they prefer the dark interiors of forests and tend to remain close to the ground. Adult pearly-eyes do not nectar on flowers, instead obtaining nutrients from sap, moist soil, dung, carrion, and decaying organic matter. All three pearly-eye species overwinter as late-instar caterpillars.

On 15 August 2016, in preparation for a US National Park Service (NPS) BioBlitz to be held in Colonial National Historical Park, VA, a survey was conducted by volunteers from the Historic Rivers Chapter of Virginia Master Naturalists (HRCVMN) and the Coastal Virginia Wildlife Observatory (CVWO) to assess butterfly activity and identify butterfly species observed at various NPS locations along the Colonial Parkway (Parkway) between Yorktown and Jamestown. In an area of the park known as Neck of Land (NOL), near Jamestown Island, a single Creole Pearly-eye and 12 Northern Pearly-eye butterflies were observed in the forest near the end of Back River Trail. This was the first known sighting of a Creole Pearly-eye in James City County and appears to be an extension northward of the range for this species on the Atlantic Seaboard.

Creoles are the least abundant of the three pearly-eye species (Glassberg, 1999; Cech & Tudor, 2005), being uncommon to rare throughout their range, and where populations do occur, they tend to be very localized. According to NatureServe (2020), the Global Conservation Status Ranks for the three pearly-eye species are G5, G4, and G4 for the Northern, Southern, and Creole, respectively. This means all three species appear to be secure globally with a low risk of extirpation. At the national and state (Virginia) levels, Northern and Southern both have Conservation Status Ranks of N4 and S4, respectively, meaning these two species are apparently secure with a low risk of extirpation. Creoles are ranked N3N4 nationally, and S3S4 in Virginia and are considered vulnerable with a moderate risk of extirpation. Host plant loss due to habitat fragmentation, degradation, or total destruction continues to be a serious risk factor for this species.

In August 2017, HRCVMN and CVWO volunteers returned to the location where pearly-eye butterflies had been observed the previous year but found none. The search was continued in other NOL areas and two Creole and three Northern Pearly-eye butterflies were observed along Old Jamestown Road Trail.

Finding Creole Pearly-eye butterflies during NOL surveys conducted in August of 2016 and 2017 suggested the presence of a previously unknown population of the species, so a citizen science project to document Creole Pearly-eyes in the NOL area was prepared and submitted to the NPS. Included in the study would be further documentation of Northern Pearly-eyes and a search for Southern Pearly-eyes.

Concurrently, the James River Association (JRA) was negotiating with the NPS to occupy the vacant Neck of Land Contact Station in order to use the building and surrounding property for educational outreach programs. An agreement was reached and JRA occupied the building in late 2017. Shortly thereafter, the NPS issued a permit for this study and both the NPS and JRA granted access to the NOL area.

The first objective of the project was to search the NOL area for native cane (*Arundinaria sp.*), host plants for Creole and Southern Pearly-eyes. Wagner (2005), Opler & Krizek (1984), and Opler & Malikul (1998) state that Creole Pearly-eye caterpillars feed only on Switch Cane (*A. tecta*), while Cech & Tudor (2005) and Opler & Malikul (1998) state that Southern Pearly-eye caterpillars feed on both Switch Cane and Giant Cane (*A. gigantea*). Taxonomists are undecided about the status of native canes, with some considering *A. tecta* to be a subspecies of *A. gigantea*. Cech & Tudor (2005) state that Northern Pearly-eyes use a variety of woodland grasses (Family Poaceae) to host their caterpillars and a survey of NOL vegetation would be conducted to search for known and potential host plants. Other objectives were to document the species, number, and distribution

of pearly-eye butterflies in the NOL area, determine the number and timing of pearly-eye broods, and document pearly-eye caterpillar feeding.

METHODS

The search for *Arundinaria* was conducted in three locations: 1) the NOL area and along the Parkway and in the forests on both sides of the Parkway extending to approximately 1.5 km east of the NOL area; 2) along the Parkway from the west end of the Powhatan Creek bridge to the Historic Jamestowne Visitor Center on Jamestown Island; and 3) on Jamestown Island via the island's Loop Drives. Roadside searches were conducted by automobile; the NOL area and forests on both sides of the Parkway east of the NOL area were searched by foot.

To document the number of pearly-eye butterflies and the number and timing of broods, weekly surveys were begun on 18 April 2018. Initially, surveys were conducted only in those areas where pearly-eyes had been observed in 2016 and 2017 (the Back River and Old Jamestown Road Trails). By 29 July, having sighted only a single Northern near the location where pearly-eye butterflies were observed in 2016, search parameters were changed. The number of surveys was increased to twice per week and the search area was expanded to include all of NOL (henceforth called the Study Area, Fig. 1). From 5 August to 17 October 2018, and from 16 May to 27 September 2019, these new parameters were followed.



Figure 1. Google Earth 2020 view of the Neck of Land and Jamestown Island regions of Colonial National Historical Park. The Study Area is outlined.

Due to the close similarity in appearance of the three pearly-eye species, each observer attempted to photograph every pearly-eye butterfly sighted. When an approaching observer caused a pearly-eye to take flight, the observer remained still and watched until the butterfly settled in a new location. Then the observer moved slowly to a position within a few meters of the butterfly where it could be viewed through binoculars and photographed. During 2018, locations where each pearly-eye butterfly was first sighted were approximated and marked on a map. During 2019, observers used hand-held GPS devices to pinpoint pearly-eye locations.

Other data recorded during surveys included: start and stop times, number of observers, general weather conditions, number and species of pearly-eye butterflies sighted, and number, stage of growth, and location of any pearly-eye caterpillars found. Temperatures and wind were measured with a hand-held device and recorded at the beginning and end of each survey. GPS readings and photographs of pearly-eye butterflies were downloaded and saved in a computer database. All other data recorded during each survey was entered into the same database and saved for future analysis.

RESULTS AND DISCUSSION

Switch Cane

During the search for Switch Cane a total of eight stands were found (Fig. 2): two stands on the north side of the Parkway at the northwest edge of the Study Area; one stand at the intersection of



Figure 2. Google Earth 2020 view of the Neck of Land and Jamestown Island regions of Colonial National Historical Park. The Study Area is outlined; stands of Switch Cane are indicated by yellow markers.

the Parkway and the entrance to the Jamestown Glasshouse site; and five stands on Jamestown Island itself, all on the south side of the Island Loop Drives.

Habitat

Pearly-eyes prefer the dark interiors of dense, bottomland woods, usually near marshes or swamps, with *Arundinaria* present in the case of Southern and Creoles. The habitat in parts of NOL and Jamestown Island fit these conditions very well (Fig. 3). Patterson (2008) classified the forests of these regions as “Coastal Plain Loblolly Pine–Oak Forest”. Trees commonly seen in the Study Area included Sweetgum (*Liquidambar styraciflua*), American Holly (*Ilex opaca*), Red Maple (*Acer rubrum*), Southern Red Oak (*Quercus falcata*), and Loblolly Pine (*Pinus taeda*), along with common vines and shrubs like Muscadine Grape (*Vitis rotundifolia*), Japanese Honeysuckle (*Lonicera japonica*), Yellow Crownbeard (*Verbesina occidentalis*), and Chinese Privet (*Ligustrum sinense*). Japanese Stiltgrass (*Microstegium vimineum*) was pervasive throughout the Study Area, but other commonly seen species included Common Woodreed (*Cinna arundinacea*), Virginia Wild Rye (*Elymus virginicus*), Broomsedge (*Andropogon virginicus*), and Soft Rush (*Juncus effusus*).



Figure 3. Typical forest habitat in the Neck of Land and Jamestown Island areas. Japanese Stiltgrass is the prevalent groundcover.

Patterson (2008) classified the surrounding wetlands as “Tidal Freshwater Marsh”. Commonly seen species included Big Cordgrass (*Spartina cynosuroides*), Smooth Cordgrass, (*S. alterniflora*), Bitter Panic Grass (*Panicum amarum*), Bottlebrush Sedge (*Carex comosa*), and Broom Sedge (*Carex scoparia*).

Caterpillars

The Alabama Butterfly Atlas (2020) states that Creole Pearly-eye caterpillars chew “a squared notch into cane leaves, which is typical of the satyrs.” Ogard & Bright (2010) state that most satyr caterpillars “chew distinctive squared-off indentations into host leaves, creating deeper, more extensive notches as they grow.” No images were provided, but during the search for *Arundinaria*, observers inspecting leaves for pearly-eye caterpillar feeding evidence found patterns matching those descriptions in all but one of the stands of Switch Cane (Fig. 4).



Figure 4. Notch in Switch Cane leaf resulting from pearly-eye caterpillar feeding. Brown edges of the chewed section indicate older activity.

While examining Switch Cane leaves for pearly-eye caterpillars, observers sometimes encountered individual leaf blades rolled lengthwise and bound by silk, or multiple leaf blades bound together lengthwise by silk. Inside the individually-rolled leaves were single caterpillars of the Lace-winged Roadside Skipper (*Amblyscirtes aesculapius*). Where several leaves had been bound together, multiple caterpillars of a Crambid snout moth (*Crocidophora pustuliferalis*) were found. Feeding damage caused by other herbivores (*e.g.*, grasshoppers and katydids) also was encountered.

Despite finding presumed pearly-eye caterpillar feeding evidence on cane leaves, no pearly-eye caterpillars were found during 2018. During 2019, feeding evidence continued to be

found but caterpillars remained elusive until 28 June. After inspecting a cane plant with fresh-looking feeding evidence on several leaves (the edges of chewed areas were still green, as opposed to having turned brown) but finding no caterpillars, a search of the leaf litter at the base of the plant was conducted. During this search, a single fourth instar pearly-eye caterpillar was discovered.

Following this discovery, the plant was carefully re-examined and a single third instar pearly-eye caterpillar was found on the underside of a leaf blade, near the tip. With its cryptic coloration and long, slender body, it was very difficult to see. Observers learned to look for caterpillars on leaves of young plants (further discussion below), and more importantly, turn leaves over and look closely near the tips of the blades. Once this technique was adopted, finding caterpillars became much easier. During the next survey on 4 July, two more third instar caterpillars were found. Then, no caterpillars were found until 22 August when a cluster of six first instar caterpillars was discovered. Between 22 August and 3 September, five different clusters of first instar caterpillars totaling 30 individuals were found (Table 1), each cluster numbering five to seven individuals (Fig. 5). No first instar caterpillars were found singly, while second and third instar caterpillars were found singly, in pairs, or sometimes mixed together in groups of three (Fig. 6). Several more leaf litter searches were conducted during 2019 but no additional late instar pearly-eye caterpillars were found.

Table 1. Number and growth stage of pearly-eye caterpillars found during Study Area surveys conducted in 2019.

Survey Date	Instar					Total Found
	1st	2nd	3rd	4th	5th	
28 Jun	—	—	2	1	—	3
4 Jul	—	—	3	—	—	3
22 Aug	6	—	—	—	—	6
27 Aug	—	2	4	—	—	6
29 Aug	11	2	5	—	—	18
3 Sep	13	—	5	—	—	18
10 Sep	—	2	—	—	—	2
12 Sep	—	—	2	—	—	2
27 Sep	—	—	2	—	—	2
Total	30	6	23	1	0	60

Almost all first and second instar caterpillars were found on leaves of young cane plants no more than about 60 cm tall, or on leaves of young stems of similar height arising from the base of mature cane plants. Third instar caterpillars were found on the leaves of plants up to about 120 cm tall. No pearly-eye caterpillar feeding evidence was observed on the highest leaves of the tallest plants (1.8 to 2.1 m high). All pearly-eye caterpillars were found on the underside of cane leaves, almost always near the tips. The pinkish to reddish horns on the heads and tails of pearly-eye

caterpillars likely contribute to camouflage (along with their coloration and body shape), making it possible for caterpillars to blend in with the tip of a leaf blade no matter which way they face (Fig. 6).



Figure 5. First instar pearly-eye caterpillars, each approximately 5 mm long, at the tip of a Switch Cane leaf blade.



Figure 6. Second and third instar pearly-eye caterpillars near the tip of a Switch Cane leaf blade.

According to Lotts & Naberhaus (2020), Creole Pearly-eye caterpillars feed at night and spend the day hiding at the base of cane plants. Ogard & Bright (2010) state that pearly-eye “caterpillars often feed at night.” Based on observations made during this study, young caterpillars (first through third instars) appear to remain on cane leaves both day and night to feed, while older caterpillars (fourth and fifth instars) descend cane stems to spend the day concealed in leaf litter on the ground, then ascend cane stems to feed on cane leaves during the night. The timing of these movements is not known.

Both Creole and Southern Pearly-eyes use Switch Cane as a host plant but since only three Southern Pearly-eyes were found during this study, the majority of pearly-eye caterpillar feeding evidence observed must have been caused by Creole Pearly-eye caterpillars. Since caterpillars of both species look identical, it is impossible to know how many Southern Pearly-eye caterpillars may have been present among the 60 caterpillars found during 2019.

Pearly-eye Butterfly Surveys

During each survey, observers walked in unison along a loosely-defined route through the Study Area, spacing themselves approximately five meters apart in a line perpendicular to the survey route. Observers adjusted their individual positions as needed when encountering obstacles, difficult terrain, or to follow a pearly-eye butterfly. The route for each subsequent survey was adjusted to the left or right of the last line traversed in order to cover as much of the Study Area as possible over time. Observers had to re-establish their search line numerous times during each survey. When five to seven observers were present for a survey, two groups were formed and each group searched a different section of the Survey Area. Observers always inspected the two stands of Switch Cane in the Study Area for evidence of pearly-eye caterpillar feeding and the presence of pearly-eye caterpillars.

During 2018, a total of 35 butterfly surveys were conducted. No surveys were possible during the weeks of 13 May and 22 July due to inclement weather. During 2019, a total of 36 surveys were conducted. Only one survey per week was possible during the weeks of 28 July, 4 August, 1 September, and 15 September due to inclement weather; surveys conducted on 31 July and 13 August were curtailed by rain.

Except as noted above, weather conditions were generally good during surveys, with clear to partly cloudy skies and calm or light winds. In 2018, survey temperatures averaged 30.2 C (range = 21 to 34 C). In 2019, survey temperatures averaged 28.3 C (range = 20 to 33 C). Humidity was not measured, but conditions were muggy throughout most of June through September each year.

The number of observers participating in a survey was typically two to four, but ranged from as few as one to as many as seven. The average time spent per survey during 2018 was 1.9 h (range = 45 min to 3.5 h), with observers collectively spending 134.7 h conducting surveys. During 2019, the average time spent per survey was 2.6 h (range = 1.5 to 4.25 h), with observers collectively spending 347.4 h conducting surveys. The 2018 data reflect the much smaller area of NOL surveyed during 18 April to 29 July.

Surveys were conducted at varying times of the day, depending on the availability of observers and the weather. Some surveys began as early as 9:00 AM while other surveys began as late as 4:00 PM. Surveys conducted during 2018 had an average start time of 1:30 PM and an

average end time of 3:30 PM. Surveys conducted during 2019 had an average start time of 10:45 AM and an average end time of 1:40 PM.

Most of the pearly-eye butterflies encountered by observers were concealed in Japanese Stiltgrass, the predominant forest undergrowth, taking flight only when observers neared their resting places. Disturbed butterflies usually re-settled quickly in the Stiltgrass or on a tree trunk or branch within several meters of their previous perch. However, some flew up to 10 m or more and in several cases, observers lost sight of them before they could be viewed through binoculars and photographed.

During 2018, 116 pearly-eyes were sighted, of which 106 were photographed. Careful examination of these photographs revealed 24 individuals had been photographed more than once during a survey, resulting in 28 duplicate images. The duplicates were eliminated, leaving 78 photographed sightings. Five of those could not be identified to species and the remaining 73 were identified as 55 Northern, 17 Creole, and one Southern Pearly-eye. The 10 unphotographed sightings were visually identifiable only as pearly-eyes.

Fig. 7 shows the approximate locations where pearly-eye butterflies were first sighted

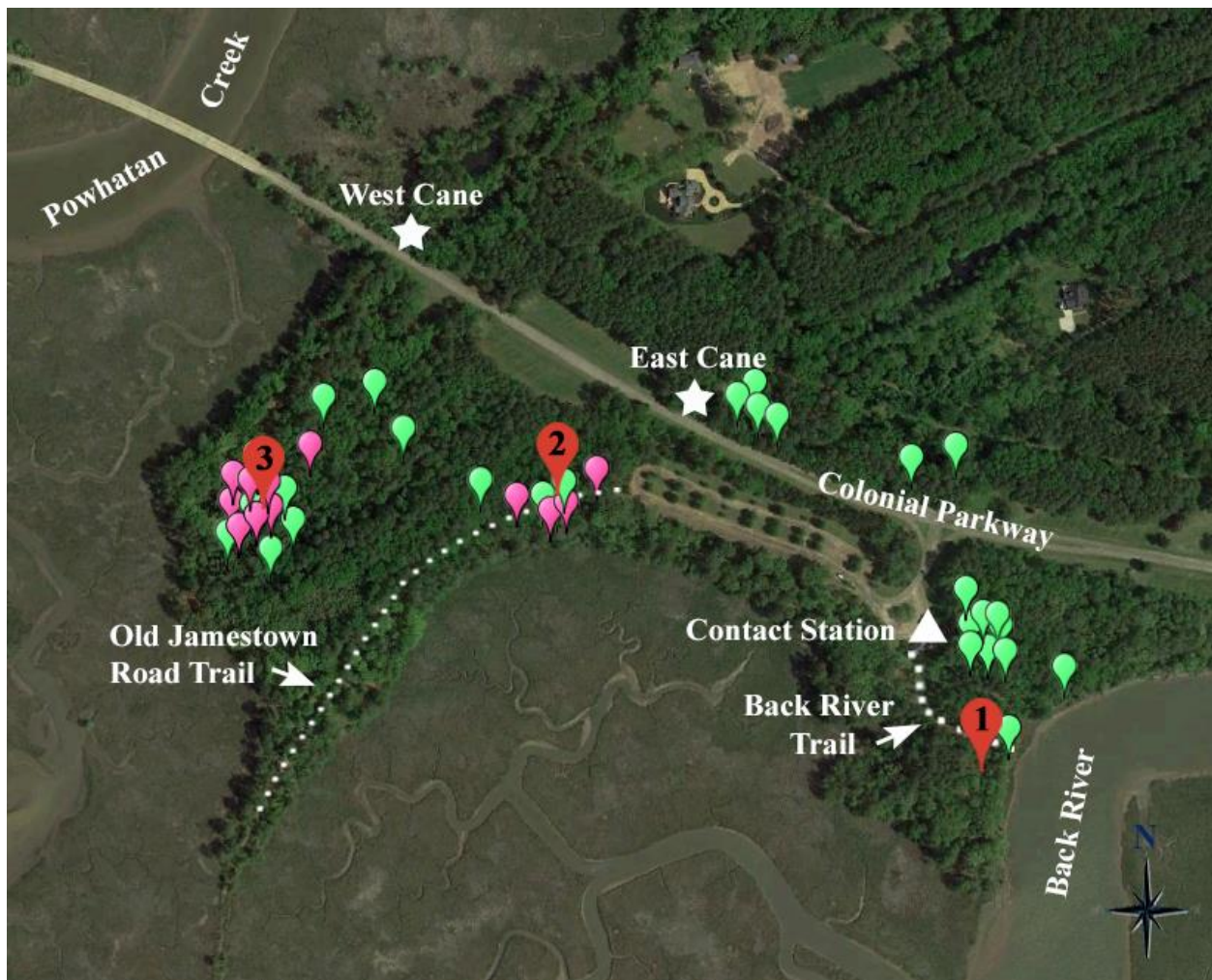


Figure 7. Google Earth 2020 view of the Survey Area showing approximate locations where pearly-eye butterflies were sighted in 2018. Pink markers represent Creoles; green markers represent Northern pearly-eyes. Sites 1, 2, and 3, indicated by red markers, represent locations where Creoles were sighted during 2016-2018.

during surveys conducted in 2018. Creoles were observed only in the vicinity of Sites 2 and 3; Northern sightings were more widespread. Fig. 8 shows the number of Creoles and Northern sightings observed during surveys conducted in 2018. Only one brood for each species is indicated because the areas later found to have the most butterflies were not surveyed during 18 April to 29 July when a first brood would be expected.

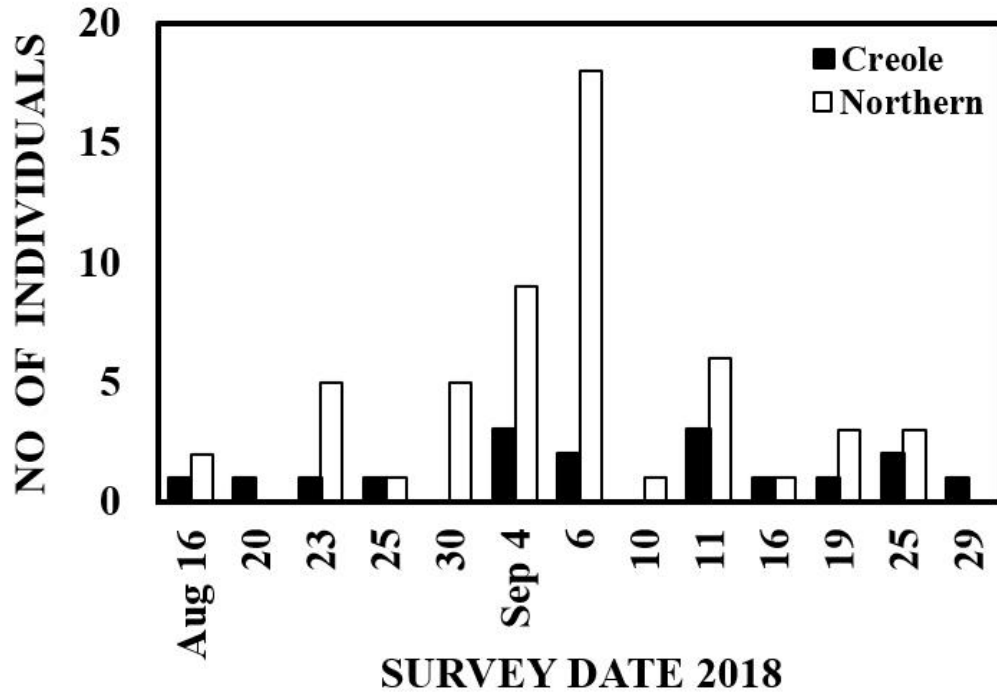


Figure 8. Number of Creole and Northern Pearly-eye butterflies sighted during 2018.

A single Southern Pearly-eye was observed near Site 3 on 4 September 2018 and represents the first known sighting of this butterfly in James City County. It also appears to be an extension of their range northward. This discovery was not unexpected because Creoles and Southern Pearly-eyes have very similar ranges, often occur together in similar habitats, and both use Switch Cane as a caterpillar host plant (Glassberg, 1999; Cech & Tudor, 2005; Alabama Butterfly Atlas, 2020). Two more Southern Pearly-eyes were documented during 2019: the same individual on 16 and 18 May near Site 4, and a second individual on 10 July between Sites 3 and 4.

During 2019, a total of 913 pearly-eye sightings were recorded, of which 745 were photographed. Careful examination of these photographs revealed 126 individuals had been photographed more than once during a survey, resulting in 173 duplicate images. The duplicates were eliminated, leaving 572 photographed sightings. Seven of those could not be identified to species and the remaining 565 were identified as 413 Northern, 149 Creole, and two Southern Pearly-eyes. The 168 unphotographed sightings were visually identifiable only as pearly-eyes.

According to Opler & Krizek (1984) and Opler & Malikul (1998), Virginia has two broods of both Creole and Northern Pearly-eyes from approximately May to September. The number of Creole and Northern Pearly-eye butterflies observed during 2019 are shown in Figs. 9 and 10, respectively, and as expected, two broods are clearly shown for both species within the reported

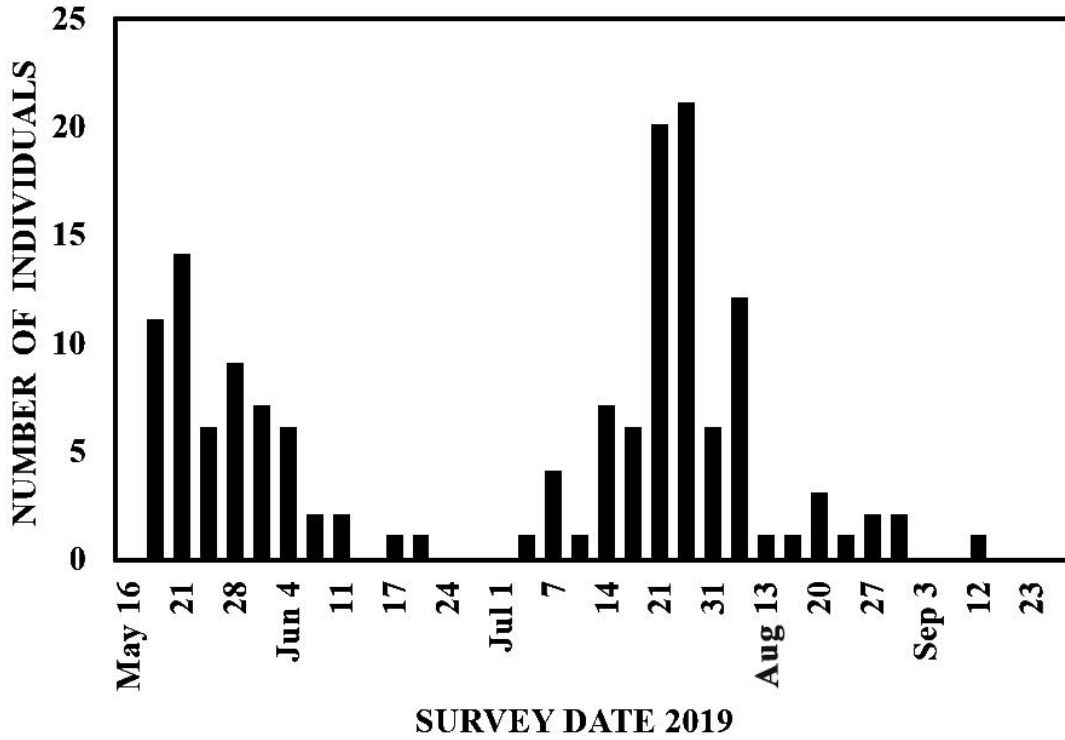


Figure 9. Number of Creole Pearly-eye butterflies sighted during 2019.

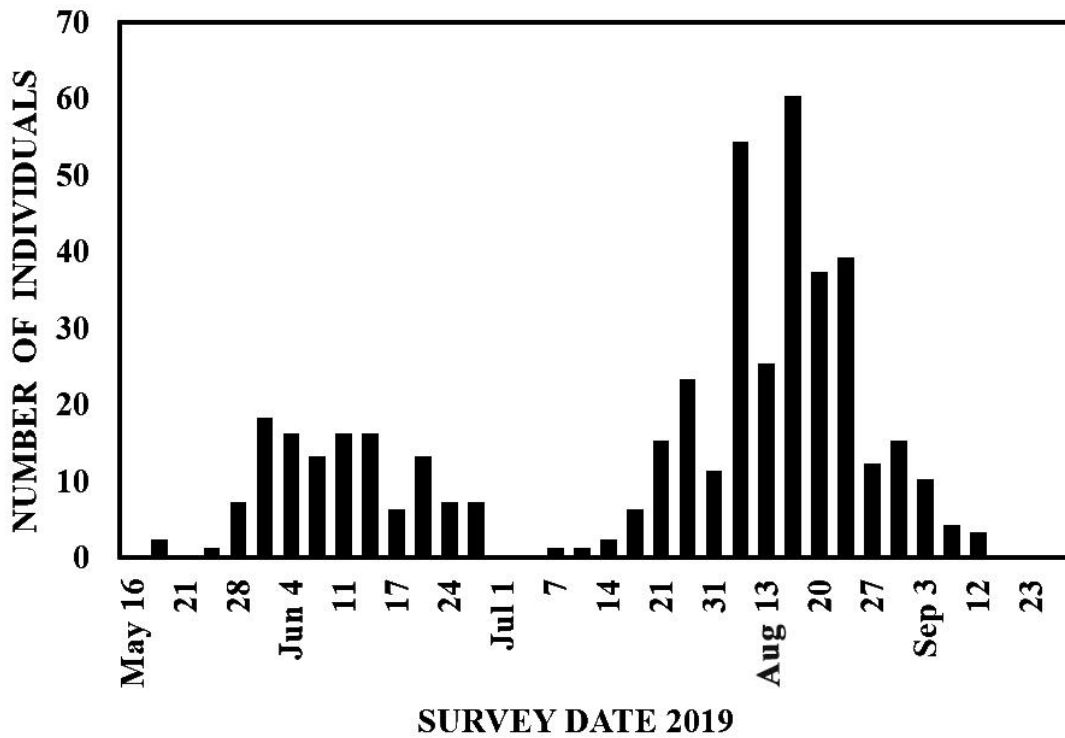


Figure 10. Number of Northern Pearly-eye butterflies sighted during 2019.

time frame. Having sighted only three Southern Pearly-eyes during this study, it is not possible to say how many broods of Southern Pearly-eyes occur in the NOL area. However, the timing of Southern sightings (May, July, and September) certainly suggests the possibility of three broods. This would be consistent with the above authors reporting three broods for Southern Pearly-eyes.

After finding the two stands of Switch Cane in the Study Area, observers expected to regularly encounter Creole and possibly Southern Pearly-eye butterflies in or near one or both stands. However, none were observed there during surveys conducted in 2018, and while four pearly-eyes were observed in the east stand of cane during 2019, three of them were Northern Pearly-eyes. The fourth was a Creole, which appeared to be very fresh, likely recently eclosed. Instead, Creoles and Southern Pearly-eyes were observed well away from both stands of cane, the majority in the forest across the Parkway from the west stand of cane (Fig. 11).

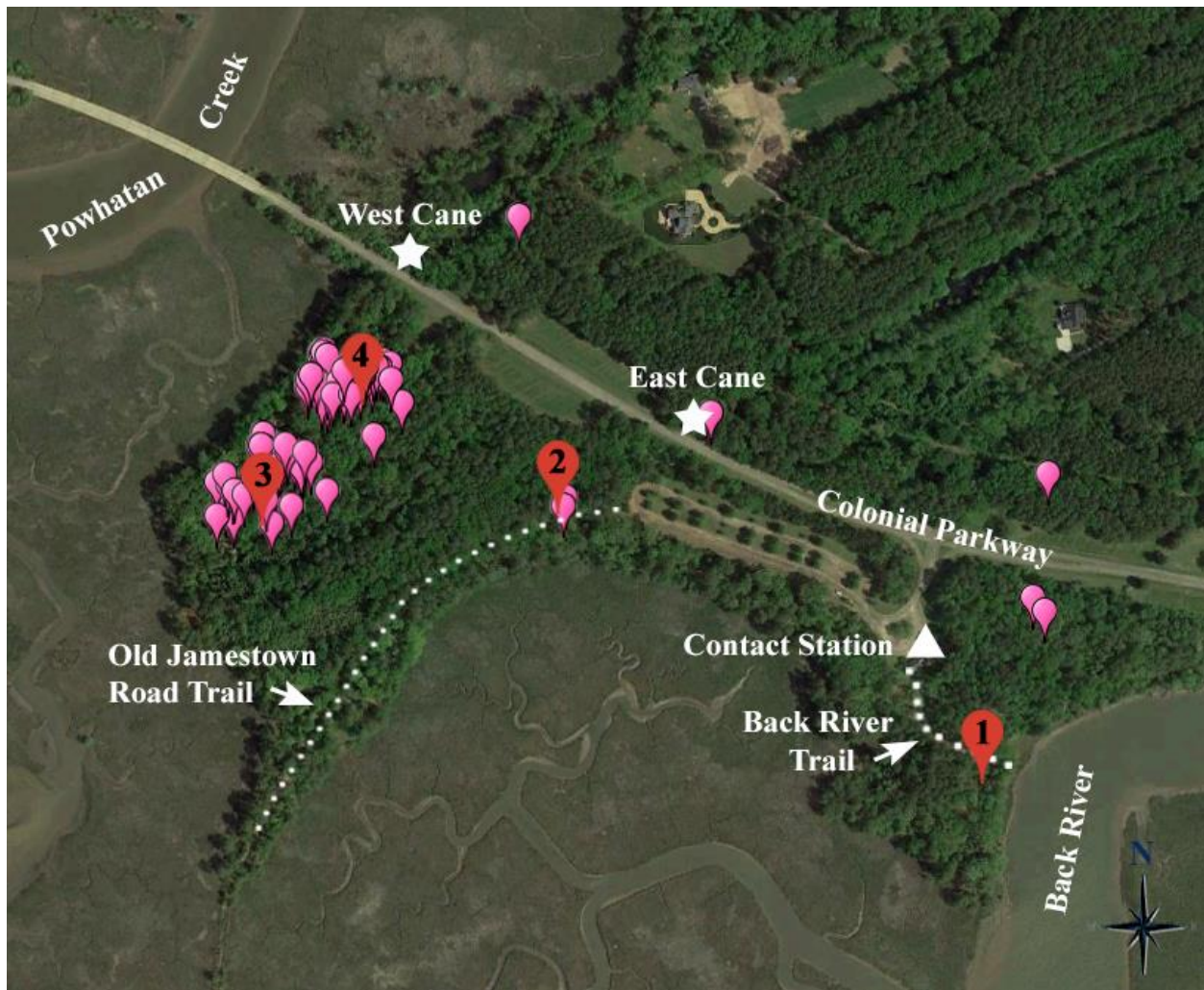


Figure 11. Google Earth 2020 map showing locations where Creole Pearly-eye butterflies were sighted in 2019; Sites 1, 2, 3, and 4, indicated by red markers, represent locations where Creoles were sighted during 2016-2019.

All three pearly-eye species are reported to be most active during late afternoon or twilight hours, or on cloudy days (Opler & Krizek 1984; Tveten & Tveten 1996; Cech & Tudor 2005; Belth 2013; Butterflies of Massachusetts 2020). In 2018, two surveys were conducted during the

hours of 9:30 AM to 12:30 PM under completely overcast conditions, but no pearly-eye butterfly activity was observed (butterflies taking flight after being disturbed by the approach of an observer was not considered active flight). In 2019, three surveys were conducted under completely overcast conditions. One was conducted during the hours of 9:00 AM to Noon, the other two during the hours of 1:30 PM to 4:30 PM. No pearly-eye activity was observed during the morning survey, but observers did encounter pearly-eye butterflies actively flying during both afternoon surveys. These observations suggest that pearly-eyes are not active all day on cloudy days, but become active only later in the day.

The activity observed appeared to be territorial behavior associated with mating, viz, perched males waiting for the opportunity to mate with a passing female or chase off rival males or other intruders. In an area roughly 20 m in diameter, eight to 10 pearly-eye butterflies were observed actively flying near the ground, while two other pearly-eyes were observed perched head down approximately two meters above ground on different tree trunks; perched individuals were identified as Northern and were assumed to be males; actively flying butterflies were identifiable visually as pearly-eyes but the species could not be determined. Observers stood in the area and watched as a perched individual left its vantage point to investigate a passing butterfly, often pursuing that individual in tight circles for several seconds or more. Then the first individual ceased its pursuit and returned to a tree trunk (often the same one) to resume its vigil. Sometimes three pearly-eyes became involved in these short-lived pursuits. Even a passing black morph Eastern Tiger Swallowtail (*Papilio glaucus*) was chased by one of the perched Northern. This behavior was witnessed multiple times as observers watched for about 10 min during each of the two overcast afternoon surveys.

The absence of adult Creoles and Southern in or near the two stands of Study Area cane, as well as their presence in two fairly specific locations (Sites 3 and 4, Fig. 11) is a mystery. Both stands of cane are located adjacent to the Parkway with their southern edges exposed, so it would seem natural following eclosure for butterflies to fly away from the Parkway and toward the darker forest interior. However, they did not do this, choosing instead to fly across the open Parkway and into the forest well away from their host plants, influenced by factors not apparent to observers.

Northern Pearly-eyes were sighted throughout the Study Area (Fig. 12), although there were three locations where they were sighted in greater numbers: between Sites 3 and 4, west of the Contact Station, and across the Parkway northeast of the Contact Station. An obvious benefit of such concentrations is that both sexes are present in higher numbers and opportunities for successful matings are greatly increased. When different pearly-eye species occupy the same habitat, there may be a natural predilection, perhaps even a pheromonal component, for comingling. Thus, the presence of large numbers of Northern in the vicinity of Sites 3 and 4 may have been a factor attracting Creoles and Southern to that area, or perhaps better food resources were available, attracting all three species.

According to Porter (2016), finding all three pearly-eye species together is a rare event. Upon finding all three pearly-eye species at the same time in the Tallasse Forest in Athens-Clarke County, Georgia, he commented: “The presence of three virtually indistinguishable, but genetically distinct, species at the same time and in the same place is almost unheard of outside the tropics.” Pyle (2010) reported finding all three pearly-eye species at the same time on a farm in southern Illinois, and Cech & Tudor (2005) state that all three pearly-eye species can be found together in parts of Arkansas.

As mentioned previously, Northern Pearly-eyes use a variety of woodland grasses as host plants for their caterpillars. According to Virginia Botanical Associates (2020), several of these

grasses [Bearded Shorthusk (*Brachyelytrum erectum*), White Cutgrass (*Leersia virginica*), Bitter Panic Grass (*Panicum amarum*), and Velvet Panic Grass (*Dichanthelium scoparium*)] occur in James City County, but only the latter two were found in the Study Area. While it is possible that some Northern Pearly-eyes use these plants as hosts, none were found in numbers large enough to support the population of Northern Pearly-eyes encountered in the Study Area.

The Maryland Biodiversity Project (2020) and NABA-NJ (2020) indicate that Northern Pearly-eyes in Maryland and New Jersey have adapted to using Japanese Stiltgrass as a host plant. Based on survey results, it appears that Northern Pearly-eyes in the Study Area also have adapted to using Stiltgrass as a host plant because those sections of the Study Area with the highest number of Northern sightings also had the greatest abundance of Stiltgrass (Fig. 12).

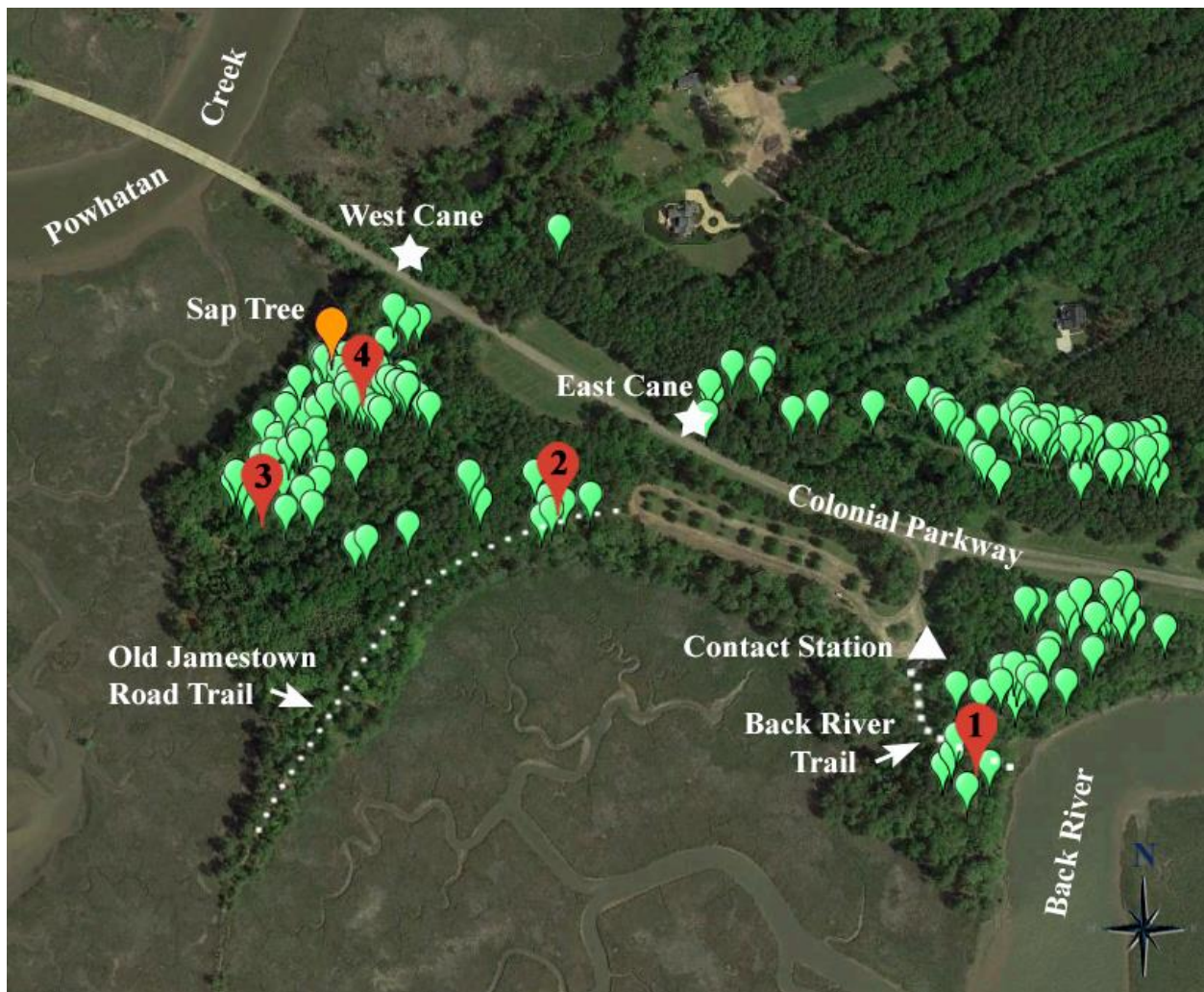


Figure 12. Google Earth 2020 map showing locations where Northern Pearly-eye butterflies were sighted in 2019; Sites 1, 2, 3, and 4, indicated by red markers, represent locations where Creoles were sighted during 2016-2019.

During the initial 2018 search for *Arundinaria*, it was noted that Stiltgrass was present in the forests on both sides of the Parkway east of the Study Area. The plant was not widespread in the forest on the south side of the Parkway, but considerably more was growing in the forest on the north side of the Parkway (although not as extensively as in the Study Area). This suggested

that Northern Pearly-eyes might be present in one or both forests, but no pearly-eyes were sighted in either forest during foot searches conducted on 29 June, 25 July, and 21 August 2019. During the Jamestown Island search for cane, a single Creole and a single Northern Pearly-eye butterfly were sighted near the first stand east of where the 3-mile Loop Drive splits off from the 5-mile Loop Drive (Fig. 2).

Pearly-eye Butterfly Identification

After examining many hundreds of pearly-eye photographs, one thing became very clear: there is a lot of variation within and between characters and no single character can be relied on for identifying any pearly-eye species. This includes the “diagnostic” orange antennal clubs of Southern Pearly-eyes. Northerns and Creoles have black antennal clubs with orange tips, so this would seem to be a foolproof method for identifying as a Southern any pearly-eye with orange antennal clubs. However, this proved not to be the case. Of the 638 pearly-eye photographs taken during this study (excluding duplicates and those not identifiable to species), images of 308 Northerns, 131 Creoles, and three Southern clearly showed both antennae. Among the Creole images was one individual with two orange antennal clubs and another individual with one orange antennal club and one “normal” antennal club. Whether rare genetic anomalies or a sign of interbreeding, this demonstrates the need to consult multiple resources and use a combination of characters to properly identify pearly-eye butterflies. It also stresses the importance of taking good photographs to help with identification.

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REFERENCES

- Alabama Butterfly Atlas. 2020. Creole Pearly-eye. <http://www.alabama.butterflyatlas.usf.edu/>. (Accessed 13 September 2020).
- Belth, J. E. 2013. *Butterflies of Indiana: A Field Guide*. Indiana University Press, Bloomington. 344 pp.
- Butterflies of Massachusetts. 2020. Northern Pearly-eye. <http://www.butterflies-ofmassachusetts.net/>. (Accessed 11 September 2020).

- Cassie, B., J. Glassberg, A. Swengel, & G. Tudor. 2001. Checklist & English Names of North American Butterflies, Second Edition. North American Butterfly Association, Morristown, NJ. <https://www.naba.org/>. (Accessed 10 September 2020).
- Cech, R., & G. Tudor. 2005. Butterflies of the East Coast: An Observer's Guide. Princeton University Press, Princeton and Oxford. 345 pp.
- Glassberg, J. 1999. Butterflies through Binoculars: The East. Oxford University Press, New York and Oxford. 400 pp.
- Lotts, K., & T. Naberhaus, coordinators. 2020. Butterflies and Moths of North America. <http://www.butterfliesandmoths.org>. (Accessed 13 September 2020).
- Maryland Biodiversity Project. 2020. Northern Pearly-eye. <https://www.maryland-biodiversity.com/>. (Accessed 10 September 2020).
- NABA-NJ. 2020. North American Butterfly Association – North Jersey Butterfly Club. <https://www.naba.org/chapters/nabanj/>. (Accessed 10 September 2020).
- NatureServe. 2020. NatureServe Explorer: An Online Encyclopedia of Life. Version 7.1. Arlington, Virginia. <http://explorer.natureserve.org>. (Accessed 3 October 2020).
- Ogard, P. H., & S. C. Bright. 2010. Butterflies of Alabama: Glimpses into Their Lives. University of Alabama Press, Tuscaloosa. 512 pp.
- Opler, P. A., & G. O. Krizek. 1984. Butterflies East of the Great Plains: An Illustrated Natural History. The Johns Hopkins University Press, Baltimore. 294 pp.
- Opler, P. A., & V. Malikul. 1998. A Field Guide to Eastern Butterflies. Houghton Mifflin Company, Boston and New York. 500 pp.
- Patterson, K. D. 2008. Vegetation Classification and Mapping at Colonial National Historical Park, Virginia. Technical Report NPS/NER/NRTR-2008/129. National Park Service, Philadelphia, PA. 369 pp.
- Porter, J. W. 2016. John Abbott and the Pearly-eye Butterflies of Athens-Clarke County. Excerpt from an August 25 speech delivered at the University of Georgia, Athens.
- Pyle, R. M. 2010. Mariposa Road: The First Butterfly Big Year. Houghton-Mifflin-Harcourt, Boston and New York. 558 pp.
- Tveten, J., & G. Tveten. 1996. Butterflies of Houston and Southeast Texas. University of Texas Press, Austin. 304 pp.
- Virginia Botanical Associates. 2020. Digital Atlas of the Virginia Flora. c/o Virginia Botanical Associates, Blacksburg, VA. <http://vaplantatlas.org/>. (Accessed 28 August 2020).
- Wagner, D. L. 2005. Caterpillars of Eastern North America. Princeton University Press, Princeton and Oxford. 512 pp.