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Determination of a new spring-flying species of the *Pterourus glaucus* complex (Papilionidae) in southern New England

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ABSTRACT. The *Pterourus glaucus* complex in three southern New England states is analyzed for cryptic speciation. What was historically considered to be one species, *P. glaucus* (Linnaeus, 1758), was recently split to separate *P. canadensis* (Rothschild & Jordan, 1906) at species rank (Hagen et al., 1991). Additionally, *P. appalachiensis* Pavulaan & Wright, 2002, was described as an Appalachian Mountain endemic. The western member of the complex, *P. rutulus* (Lucas, 1852), has frequently been considered a subspecies of *P. glaucus* (Scott, 1986; Tyler, Brown & Wilson, 1994), as was *P. alexiares* (Höpffer, 1866) (Tyler, Brown & Wilson, 1994). Recently, a bimodal emergence pattern was identified in populations across a regional band stretching from southern New England, through central New York (Hagen & Lederhouse, 1985), northeastern Pennsylvania (Monroe & Wright, 2017) and into southern Ontario (Schmidt, 2020). This bimodal pattern encompasses two univoltine taxa: an earlier, spring-flying taxon with slightly closer morphological affinity to *canadensis*; and a later, summer-flying taxon with a closer affinity to *glaucus*. The early-flight taxon is here described as a new species, most likely of hybrid origin similar to *appalachiensis*. The late-flight taxon, tentatively referred to as the "Mid-Summer Tiger Swallowtail" (Wang, 2017; Schmidt, 2020), also likely of hybrid origin, appears to be undergoing rampant hybridization with glaucus in southern New England, though there is evidence it has achieved early stages of speciation in Ontario.

Additional key words: Rhode Island, Massachusetts, Connecticut, bimodal flight, early-flight, late-flight, hybrid introgression, Eastern Tiger Swallowtail, Canadian Tiger Swallowtail, New England Tiger Swallowtail, Mid-Summer Tiger Swallowtail, Björk Guðmundsdóttir, *bjorkae*.

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INTRODUCTION

The original focus of this paper was on observations of 'Tiger Swallowtail' flights in Rhode Island in preparation of a Rhode Island field guide. Yet it soon became apparent that similar flights were observed throughout much of Connecticut and Massachusetts. The availability of reasonably "good" condition paratypes from the study region is very limited, thus it was necessary to examine several hundred images from internet sources, such as iNaturalist and BAMONA, institutional digital collections, as well as from contributors of photographic imagery in the region, mainly members of the Massachusetts Butterfly Club and Connecticut Butterfly Association. Imagery was examined for morphology. Only a small percentage of "live" images was chosen to represent each of the species. [Due to space limitations here, these images will be published in a future issue of the News of The International Lepidoptera Survey]. It might be noted that institutional collections are often difficult to access for avocational lepidopterologists due to limited individual financial, travel and time resources. Thus, reliance on digital imagery was used for most parts of this study.

Many images had to be discounted due to various insufficiencies in the images (poor angle, shaded wings, distance from camera). Thus many spring brood individuals in the region have been misidentified as *P. canadensis*, thus giving a false picture of the range of *canadensis,* especially in Massachusetts (Stichter, 2015). Individuals determined as potentially *canadensis* have rarely been taken as far south as Rhode Island. There is a problem identifying individuals solely on the basis of the ventral forewing's yellow submarginal band. The new species, dubbed the "New England Tiger Swallowtail" and most *P. glaucus* individuals in New England, possess this same ventral marginal band. Differentiating the three species and a newly-recognized, potential summer hybrid (Wang, 2017; Schmidt, 2020; Ontario Butterfly Atlas online, 2020; Butterflies and Moths.org, 2020) is often difficult, with the presence of many intermediate variants. Thus, local observations, rearing or breeding of each is necessary to obtain a more definitive answer.

The butterfly commonly known for over 260 years as the "Tiger Swallowtail" (Miller, 1992; many other authors) and more recently as the "Eastern Tiger Swallowtail" (NABA, 1995) has been the subject of intensive investigation in recent years in regard to it its ecology, genetics, evolution, and systematics (Hagen & Lederhouse, 1985; Hagen et al., 1991; Pavulaan & Wright, 2002; Scriber, 1996; Scriber et al., 1995). Linnaeus (1758) first described *Papilio glaucus* from a black female specimen. He also described *Papilio antilochus* (1758) from a typical yellow male specimen, assuming this to be a different species. Subsequently, Linnaeus (1771) described *Papilio turnus* from a typical yellow female, again assuming this to be a different species. Cramer (1775) then described *Papilio alcidamas* from a typical male specimen. Today, these names fall under *P. glaucus* as synonyms.

In more recent years, Brower (1959), Hagen & Scriber (1991), and Scriber (1996) recognized the close relationships of the various North American Tiger Swallowtail species, and assigned these as members of the *Papilio glaucus* group (or complex): *glaucus* Linnaeus, 1758; *rutulus* Lucas, 1852; *eurymedon* Lucas, 1852; *alexiares* Höpffer, 1866; *multicaudata* W. F. Kirby, 1884; *canadensis* Rothschild & Jordan, 1906. *P. pilumnus* Boisduval, 1836, despite its superficial appearance as a "Tiger Swallowtail", is recognized as a member of the *P. troilus* species group (Brower, 1959; Scriber, 1996). Additional subspecies and synonyms have been described. Pavulaan & Wright (2002) described new species *P. appalachiensis* from the Appalachian Mountain region.

THE *PTEROURUS GLAUCUS* (LINNAEUS, 1758) COMPLEX IN SOUTHERN NEW ENGLAND

Discussion: What has traditionally been recognized as the familiar "Tiger Swallowtail" is now recognized by lepidopterologists as a group of closely-related butterflies in evolutionary flux, with relationships not fully-understood by biologists at this time, and therefore in a state of taxonomic uncertainty. Stichter (2015) stated it well: "Ironically, most of the butterflies we currently call this species [*P. glaucus*] in Massachusetts may actually be part of a large northern hybrid complex, or hybrid swarm, which differs genetically from the classic Eastern Tiger Swallowtail found south of Pennsylvania." Formerly considered a subspecies of *Pterourus glaucus, P. canadensis* was recently elevated to full-species rank (Hagen et al., 1991). Recent studies by other researchers have revealed a much more complex picture, involving past and present hybridization, leading to hybrid swarms, zones of introgression, "early" and "late" flights, "hybrid" summer broods, and bimodal emergence patterns (Denno & McClure, 1983; Hagen, 1990; Hagen & Lederhouse, 1985; Hagen & Scriber, 1989; Hagen et al., 1991; Luebke et al., 1988;

Ording, 2008; Remington, 1968; Rockey et al., 1987a, 1987b; Scriber, 1988, 1990a, 1990b, 1996, 1998, 2002a, 2002b; Scriber & Ording, 2005; Ording et al., 2009; Schmidt, 2020; Scriber et al., 1991, 1998, 2002, 2003, 2008; Sperling, 1990; Stump et al., 2003; Tesar & Scriber, 2000). Most recently, the discovery and confirmation of a previously undocumented Appalachian Mountain species, *Pterourus appalachiensis* (Pavulaan & Wright, 2002) was determined to have evolved via hybrid introgression (Kunte et al., 2011; Ording, 2008).

Much has been studied of the relationship between *glaucus* and *canadensis* in Michigan and Wisconsin, where the two species meet in a very narrow contact zone, with very limited gene flow across the zone. The contact zone, often referred to as a "hybrid zone" stretches across the Carolinian zone in southern Ontario, which serves as a divide between northern and southern biota. The *glaucus*/*canadensis* contact zone is limited by a number of ecological, climatological and biological factors that prevent southern *glaucus* from producing a second full generation north of the contact zone. Scriber (1996) observed: "A seasonal accumulation of degree-days fewer than 1,400 selects intensively against completion of a second generation for *P. glaucus*." More recent observations indicate that this contact zone falls apart in southern New England and adjacent regions, where four distinct taxa come into broad sympatric contact. A bimodal emergence pattern of two recently evolved "hybrid" species (Hagen & Lederhouse, 1985; Ording, 2008) further complicates the relationship of *glaucus* and *canadensis* in southern New England. Rampant hybridization, especially during the summer months, is a possibility, clouding our current understanding of relationships.

Most lepidopterologists and butterfly observers in this region are therefore not fully aware of the complex relationship between the several taxa, thus generally reporting all sightings as "Eastern Tiger Swallowtails" or "Canadian Tiger Swallowtails" (specifically in Massachusetts). Presently, it is very difficult for most observers to distinguish these entities due to overall similarity of adult features (yellow and black striped pattern), but careful examination of features reveals differences. The relationship of the various broods and phenotypes well documented in Rhode Island will be addressed here. Without extensive sampling, field observations, rearing studies and conclusive mtDNA analysis, it will be very difficult to unravel the relationship of the various potential taxa, and may be up to the next generation of lepidopterologists to resolve with certainty. A "split" course is followed here, though from a different approach than traditional treatments.

What is known is that in Rhode Island there are two distinct phenotypes in early spring. One is clearly the spring phenotype of southeastern, bivoltine *Pterourus glaucus glaucus* (Figs. 12-17); the other is a univoltine taxon bearing a striking resemblance to *Pterourus canadensis* (Figs. 18-21). The univoltine spring-flying taxon is treated here as "near-*canadensis*", even though it is inconclusive that *canadensis* ranges into southern New England. To complicate matters further, *glaucus* may produce *canadensis*-like spring individuals that cannot be differentiated from true *canadensis* solely by wing morphology. These can only be differentiated by rearing the larvae. This can be tested by introducing first instar larvae to several hosts, some of which are toxic to either species. For example, *Liriodendron tulipifera* (Tulip Poplar) and *Ptelea trifoliata* (Hop Tree or Wafer Ash) are used by *glaucus* larvae but are toxic to *canadensis* larvae. Conversely, *Populus tremuloides* (Quaking Aspen) and *Betula papyrifera* (Paper Birch) are used by *canadensis* larvae but are toxic to *glaucus* larvae. Interestingly, *Prunus serotina* (Black Cherry) and *Fraxinus americana* (White Ash) are acceptable to both species. In this case, the general rule is, those larvae from spring-flight females which produce chrysalids that produce a subsequent generation of summer adults in the same year will be *glaucus*, while those producing chrysalids that go into hibernal diapause and produce adults in the spring of next year will be *canadensis*. However, the two taxa comprising the bimodal emergence pattern: the "New England Tiger Swallowtail" and the "Mid-Summer Tiger Swallowtail" require rearing studies to determine specific host requirements and documentation of toxicity to the larvae. Clearly, more work is needed.

In late spring, emergence of a larger phenotype (early bimodal flight) emerges that is very similar in appearance to *canadensis* and is apparently also univoltine (Figs. 22-25). I treat this as a new species: "New England Tiger Swallowtail". In summer, the picture in southern New England gets complicated again. There appear to be two distinct phenotypes: one clearly the summer brood phenotype of southeastern, bivoltine *Pterourus glaucus* (Figs. 6-11); yet another phenotype appearing similar to the late-spring type. This latter type is referred to as the "Mid-Summer Tiger Swallowtail" (Schmidt, 2020; Ontario Butterfly Atlas online, 2020). This taxon is described as an "intergrade" between *canadensis* and *glaucus* (Acorn & Sheldon, 2016). This summer phenotype is differentiated from *glaucus* primarily by the females (Figs. 29-30, 40); the males (Figs. 31-32, 39) are somewhat difficult to differentiate from *glaucus*. This situation likely reflects a degree of postglacial hybridization and genetic introgression between *glaucus* and possibly *canadensis* (Wang, 2017; Schmidt, 2020). However, there appears to a considerable amount of hybridization ongoing to the present day in southern New England, mainly during the summer, when intermediate forms abound, making accurate visual identification difficult in many cases.

Hagen & Lederhouse (1985) conducted an extensive 11-year study of voltinism of what they referred to as *P. glaucus*. They observed a bimodal emergence pattern in central New York (Fig. 1). Two distinct emergence modes were identified during 1972-1973 observations: the first peaking in mid-June, the second peaking in mid-July. Another field study in 1983 observed only the early flight with an "extended tail" into August; the "tail" (of only single individuals during daily counts) possibly reflecting a crash in the population of the second flight in 1983, rather than an elongated flight of very low numbers following the peak of the first flight. Scudder (1889) reported such a crash in numbers, in general, from Schoharie, N.Y.: "Although generally abundant, there are certain years when they become scarce...that not one specimen was seen in 1856...while in 1858 they were among the commonest of butterflies." Interestingly, Hagen & Lederhouse discovered that both of the bimodal emergences were univoltine in nature, each showing no direct development of immature stages to producing a second annual brood, which would have emerged too late in the season to be viable. The authors concluded that the bimodal emergence pattern is genetically based. Using starch-gel electrophoresis, they determined that both flights were genetically identical to each other, but also learned that bivoltine populations of *glaucus* south of Pennsylvania were genetically distinguishable from the early emerging flight in central New York, noting that the transition between southern and northern populations appear to be abrupt [current observations in southern New England provide a different picture, in that both near-*canadensis*, *glaucus* and the bimodal flights all occur and overlap to varying degrees in southern New England]. Each of the two studied early and late flights produced hibernal-diapausing pupae which eclosed at their respective parent's flight time in the following year. They suggested that parapatric speciation was occurring in the region where bivoltine *glaucus* and univoltine *canadensis* meet in a broad transition zone, and noted that adult specimens in both of the bimodal flights in the study area were intermediate between *glaucus* and *canadensis*. This reflects what is learned in the current analysis for southern New England. The authors suggested that populations with different voltinism would become reproductively isolated due to asynchronous development of the larvae, ultimately selecting against hybridism. Ording (2008) corroborated much of Hagen & Lederhouse (1984). I add here that this leads to early speciation.

The bimodal pattern is clearly evident in the seasonal abundance graphs of Tiger Swallowtails illustrated in Hagen & Lederhouse (1985), with flight peaks in mid-June and late-July, indicating two distinct, though similar taxa, both univoltine in nature. Fig. 1 shows an adaptation of the data combining 1972, 1973 and 1983 data. Monroe & Wright (2017) recorded a similar bimodal pattern in northeastern Pennsylvania over a 22-year period, with flight peaks in early-June and early-July (Fig. 2).

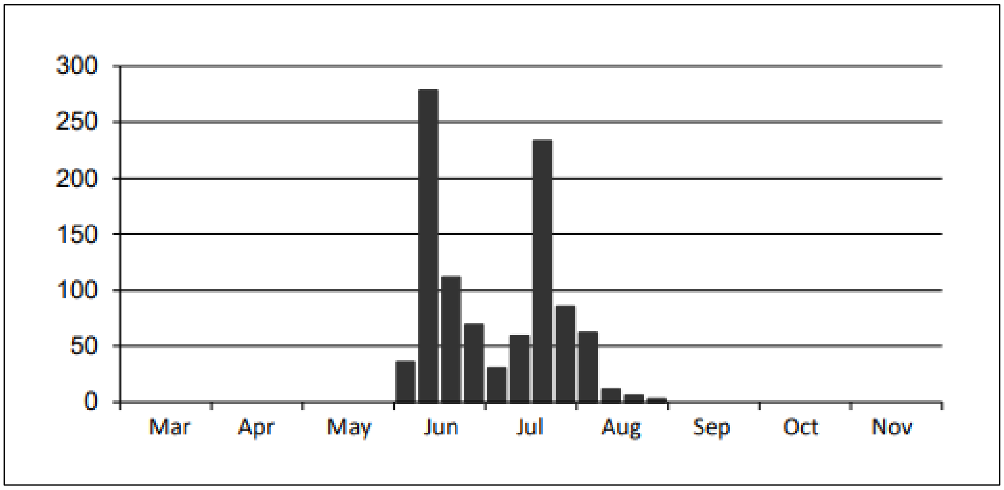

Fig. 1. Bimodal flight pattern in central New York (Hagen & Lederhouse, 1985).

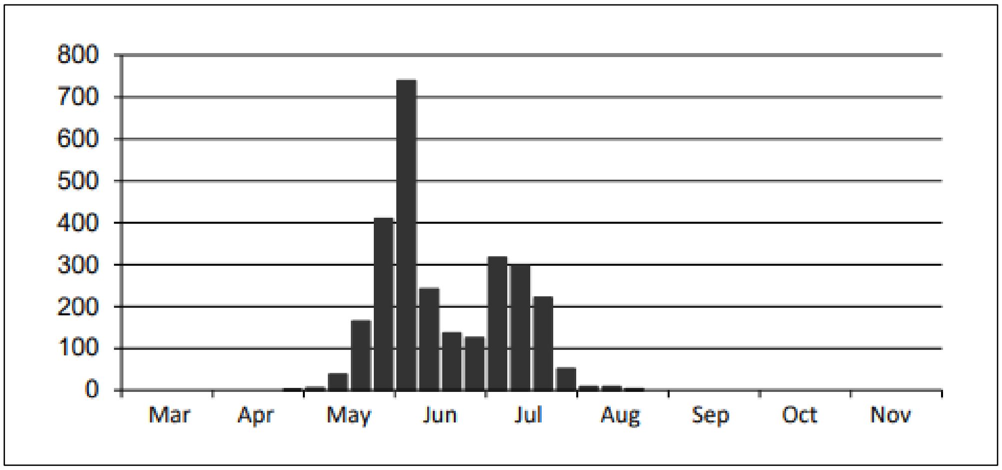

Fig. 2. Bimodal flight pattern in northeastern Pennsylvania (Monroe & Wright, 2017).

Phenograms were then composed for the three southern New England states (Figs. 3, 4 & 5). Each phenogram is inclusive of all members of the "Tiger Swallowtail complex" due to most reports being assigned to either *glaucus* or *canadensis*. Massachusetts data comes primarily from the Massachusetts Butterfly Club's database (1991-2019). Rhode Island data is based on data accumulated from a broad array of correspondences and resources (i.e. Butterfly Society of Rhode Island and Oceanstate Butterflies Yahoo discussion groups) spanning 1946-2023. Connecticut data comes primarily from the Connecticut Butterfly Association website (Field Notes, 2002-2018; recent sightings, 1980-2020), and other online resources (i.e. BAMONA, iNaturalist). The purpose of these phenograms is primarily to show the peaks and dips of abundance that will reveal a bimodal or other pattern.

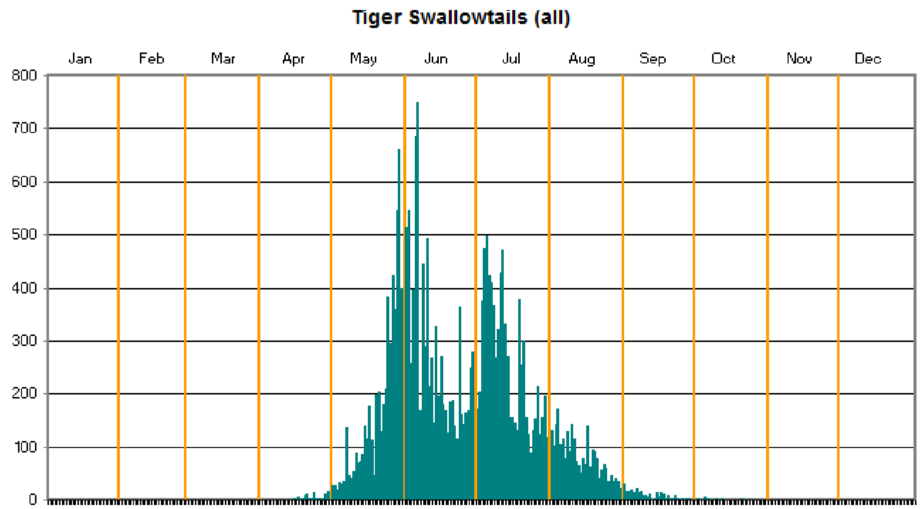

Fig. 3. Combined flight pattern in Massachusetts with bimodal pattern evident (1991-2019).

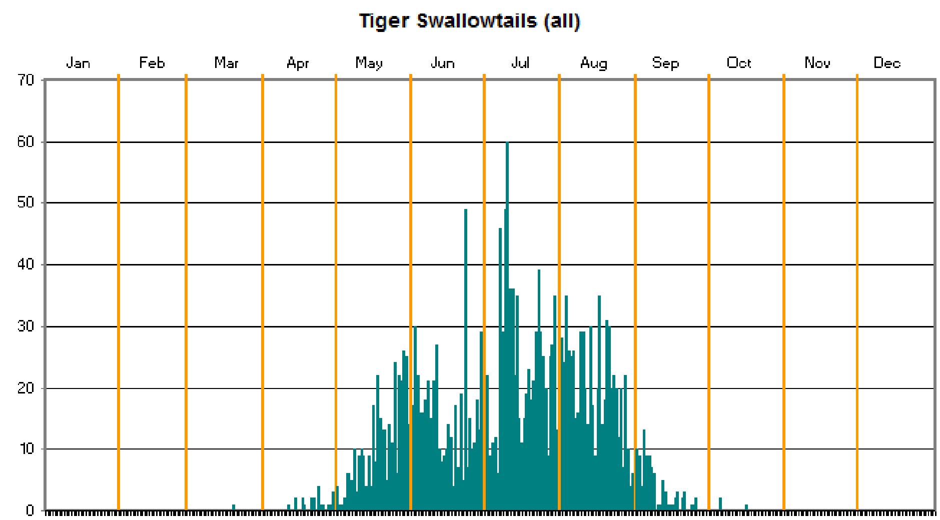

Fig. 4. Combined flight pattern in Rhode Island (1946-2023).

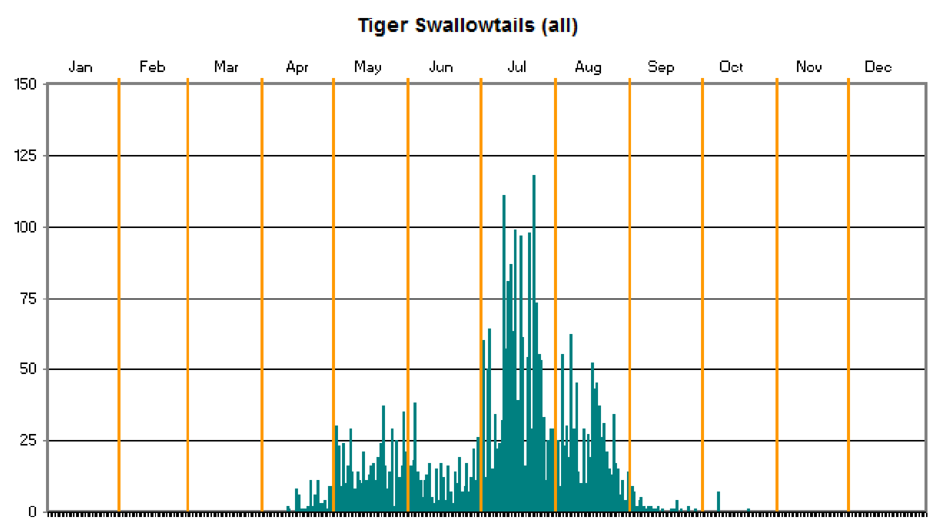

Fig. 5. Combined flight pattern in Connecticut (1980-2020).

In Massachusetts, the bimodal pattern is very evident (Fig. 3), with an early peak in late-May and early-June, and a second peak in early July. The charted bimodal peaks are much more pronounced in Massachusetts than in either Rhode Island or Connecticut. Interestingly, this places the bimodal emergence pattern precisely between what may be the northward limit of *glaucus'* hibernal diapause along the south New England coast, and south of the primary breeding range of *canadensis* in northern New England. The first peak is indicative of the univoltine "New England Tiger Swallowtail", while the second peak consists of a mix of *glaucus* and the univoltine "Mid-Summer Tiger Swallowtail", though glaucus tends to appear in the latter part of the flight period, mainly in August. As there were no verifiable images of "typical" spring brood *glaucus* (females) available in Massachusetts, it is theorized that *glaucus* is primarily a summer migrant from the southern New England coastal region, and incapable of hibernal diapause in the cold, reduced degree-day of the interior New England winter. While *canadensis* does occur regularly in northwestern Massachusetts, confusion with the "New England Tiger Swallowtail" (early bimodal flight) is apparently problematic for identification. Stichter (2015) shows the range of *canadensis* throughout all of Massachusetts except the southeastern portion of the state, but many of these records very likely pertain to the "New England Tiger Swallowtail", though it is likely that *canadensis* possibly does range considerably southward. Stichter states: "The differences and gradations between the two taxa [*glaucus* and *canadensis*] in this zone [Great Lakes to New England] are complex. Genetic differentiation and speciation are ongoing processes for these taxa in our area...and what we now call "Eastern Tiger Swallowtail" ...may in fact be a hybrid between *P. glaucus* and *P. canadensis.*"

In the Rhode Island phenogram (Fig. 4), a bimodal pattern is evident but masked by the presence of *glaucus* spring and summer broods and an early spring emergence of what is tentatively identified as "near-*canadensis*". An early peak in late-May and early-June is indicative of the flight of the "New England Tiger Swallowtail". A spring brood of *glaucus* is apparently very uncommon in Rhode Island in May and June, and contributes only negligible numbers to the cumulative sum. The presence of overwintering (diapausing) *glaucus* pupae likely depends very much on the severity of the winter during different years. The near-*canadensis* taxon similarly contributes negligible numbers. A late-June and early-July peak is indicative of the late peak of the bimodal pattern ("Mid-Summer Tiger Swallowtail"), though this flight is extended through season's end. Interestingly, *glaucus* becomes more frequent in late-July and August. There is an apparent late summer overlap of *glaucus* with the "Mid-Summer Tiger Swallowtail", thus a large degree of hybridization is possible, as indicative of many intermediate individuals that are not reliably assignable to either taxon. It is presently not determined if potential late summer hybrid pairings would produce eclosions in the following spring. Interestingly, the lack of *glaucus* in the spring and greater presence during summer is reflective of the Appalachian Mountains of northern Virginia, where *glaucus* is apparently incapable of hibernal diapause in the cold temperatures of high elevations (>2000'), yet becomes common at all elevations in the summer. This indicates the highly mobile nature of *glaucus* and its ability to repopulate peripheral habitats and regions such as southern New England annually.

In the Connecticut phenogram (Fig. 5), the bimodal pattern is difficult to discern, with *glaucus* irrupting in the summer months, likely partly from migration from adjacent New York State and partly due to second-generation recovery of surviving pupae from the harsh New England winter.

Information for neighboring regions of Vermont and New Hampshire is available but beyond the scope of this study. The Vermont Butterfly Survey revealed a dominance of *canadensis* in the spring months, while during the summer months, the "Mid-Summer Tiger Swallowtail" dominated, with only a few worn summer phenotype *glaucus* being recorded. While information in New York and Pennsylvania is available, it is also beyond the scope of this paper, though two phenograms are included here for specific areas, for comparison purposes. The Central New York phenogram (Fig. 1) is based on Hagen & Lederhouse (1985), who first documented the bimodal pattern, and the northeastern Pennsylvania phenogram (Fig. 2) is based on the personal observations of David Wright (Monroe & Wright, 2017) that clearly corroborates the pattern in New York.

The following treatment is by no means the final word on "Tiger Swallowtails" in southern New England. Much work is needed and remains a ripe field for future researchers. The extent of the bimodal pattern, the northern hibernal diapause limit of *glaucus*, the southern limit of *canadensis*, and hostplant associations all call for continued research throughout the region.

***Pterourus glaucus glaucus* (Linnaeus, 1758)**
Eastern Tiger Swallowtail

Status: In Rhode Island, the more southerly *glaucus* phenotype is not well documented by specimens, despite the widespread distribution of "Tiger Swallowtails" throughout the state, and throughout the season. However, imagery posted to various web-based resources provides adequate documentation that *glaucus* has a fair presence in the state, mainly during July and August, with a very widespread occurrence, but never common. It is relatively rare in spring, and is generally observed only as single individuals, never reported in multiples, as is frequent in the southeastern states, especially in summer.

In Massachusetts, *glaucus* is at its approximate northern limit, and is less common than near the southern New England coast, though photographic documentation shows it is present, but mainly in summer. The distinct spring form females have not been documented in available imagery. It is theorized here that perhaps *glaucus* is primarily a summer visitor to Massachusetts, coming north from the Connecticut and Rhode Island coastal region where a scant spring brood is documented. Any larval offspring of the summer flight in Massachusetts will likely not have enough time and host resources to complete growth before freezing weather sets in, causing larval mortality (Tesar & Scriber, 2000). This translates to no spring flight in Massachusetts except perhaps in rare cases and more likely in the extreme southeastern coastal portion of the state, including the islands, which have a more moderate ocean-influenced winter climate. The fact that *glaucus* produces a *canadensis*-like spring form confounds identification. Only the rearing of offspring larvae of these *canadensis*-like forms will answer that question.

In Connecticut, *glaucus* appears to be well-established, though the phenogram (Fig. 5) indicates a rather weak flight of the three spring-flying species (*glaucus*, *canadensis* and "New England Tiger Swallowtail"), whereas the summer flights of the two sympatric species (*glaucus* and "Mid-Summer Tiger Swallowtail") appear to irrupt in July. This likely reflects observations of very rapid repopulation of the region from small numbers of overwintering pupae that have survived the harsh New England winter along the coast, and/or via migration from southern New York and New Jersey. [Information for neighboring regions of New York, Vermont and New Hampshire is available but beyond the scope of this study.]

Habitat: An inhabitant of virtually all types of forested or forest-associated habitats, though mixed deciduous forests contain more of a variety of documented host trees. There are few observations in Pine-dominated forest habitats. Adults are frequently found in open field habitats and suburban gardens wherever preferred nectar sources are abundant.

Larval Hosts: Black Cherry (*Prunus serotina*) is documented by observing female oviposition and by successful rearing of the larvae in Rhode Island, and appears to be a favorite host in Connecticut and Massachusetts. Tulip Poplar (*Liriodendron tulipifera*) is also reported for Connecticut and Rhode Island; Pin Cherry (*Prunus pennsylvanica*) and Sassafras (*Sassafras albidum*) in Connecticut. In Massachusetts, additional hosts include: Choke Cherry (*Prunus virginiana*), Beach Plum (*Prunus maritima*), Japanese Flowering Cherry (*Prunus serrulata*). Other hosts, such as Ashes (*Fraxinus* sp.) and deciduous Magnolias (*Magnolia* sp.) are certainly used but so far specific reports have not been documented in New England.

Habits: In Rhode Island, adults are almost always seen in hurried flight, though adults are fond of nectar sources and will stop to feed when the opportunity arises. As with *Pterourus appalachiensis*, females may spend more of their time in the tree canopy, coming down only to feed at nectar sources or to engage in courtship rituals. In Massachusetts, apparently somewhat more frequently found at nectar sources in summer.

Broods: Two broods. **Confirmed early dates**: April 25 (Connecticut); April 2 (Massachusetts); April 25 (Rhode Island). **Confirmed late dates**: August 31 (Connecticut); November 7 (Massachusetts); October 16 (Rhode Island). The early Massachusetts date is rare, and likely reflects migration arriving from the south.

Distinguishing features and variation: The largest of the northeastern Tiger Swallowtails (especially the summer forms). Wingspan of the summer form averages 3.5" (90 mm), whereas the spring form is highly variable. The females of our four Tiger Swallowtail species are more distinct from each other than are the males. Dorsally, the yellow female individuals of *glaucus* are readily differentiated from all other southern New England "Tiger" Swallowtails by an extensive row of blue submarginal chevrons on the dorsal hindwing (Figs. 8, 10, 14, 16, 35), frequently forming into a solid blue band. In some individuals, the blue chevrons often extend onto the tornal submarginal portion of the forewing. The interior of the dorsal hindwing is generally covered by a subtle blue wash of scales. This is more evident in the black females (Fig. 10) but also variably present in yellow females. Yellow females are generally more orange-yellow (ochreous) than the other "Tiger" species with the inner portion of the wings more deeply ochreous, and the outer portion being paler yellow (Fig. 8).

Ventrally, the supposed diagnostic submarginal row of yellow lunules on the ventral forewing of New England female specimens are frequently enlarged into a solid band (Fig. 17), thus one must rely on other features for more accurate identification. However, when the submarginal lunules are fused into a band, in *glaucus* the inner edge of the band is generally strongly scalloped. The ventral hindwing is broader and more rounded, and is characterized by the strongly scalloped outer wing edge. Similarly, the postmedian boundary between interior yellow (typical females) or black (form "nigra") interior ground color and the submarginal row of blue chevrons forms a scalloped ribbon. Also, hindwing marginal lunules are shaped more like a row of crescents, frequently orange.

Males of summer generation *glaucus* (Figs. 6, 7, 12, 13, 35) are very similar to males of the other New England "Tiger" species and can easily be misidentified. Like the females, the wings are broader, the hindwing more rounded with a scalloped wing edge, and postmedian black line similarly scalloped. Males in particular have a very broad marginal black area on the hindwing dorsum, often expanding inward to encompass nearly half the hindwing area (Fig. 6).

Southern New England coastal spring individuals, similar to spring individuals of *glaucus* from more southerly reaches of North America, have the general appearance of summer individuals, only smaller (Figs. 12-17). Some male spring individuals approach the *canadensis* phenotype, thus making accurate identification difficult. By contrast, the summer brood individuals (Figs. 6-11) are dramatically larger. Black form "nigra" females (Figs. 10-11) are undocumented in spring in New England, but are occasionally encountered in the summer brood, and mainly along the southern coastal region (Mark Schenck, pers. corr.).

One reliable way to distinguish *glaucus* from either *canadensis* or the Mid-Summer Tiger Swallowtail is to examine the first instar larvae. The larvae of *glaucus* are black with a single white saddle mark centered on the back.

Comments: Approximately 20 eggs were obtained from a captive female (in spring 1983). The caterpillars were raised under identical conditions as a similar larval batch (later determined to potentially be *canadensis*), both on Black Cherry (*Prunus serotina*) and produced a second generation of typical summer form *glaucus* that same summer. The resulting adults were typical southern summer form *glaucus*. A female collected in Foster Center, R.I. on July 24, 2006 left a single egg which was reared through hibernal diapause and exposed to natural winter cold. The pupa was taken indoors and exposed to warm conditions in January. The resultant offspring, a female, emerged on February 19, 2007 (Figs. 16-17) as a typical "southern" spring form female.

Distributional County Records: Confirmed photo or specimen records for this study. **Connecticut**: Fairfield, Hartford, Litchfield, New Haven, New London. **Massachusetts**: Berkshire, Hampden, Middlesex, Norfolk, Worcester. **Rhode Island**: Bristol, Kent, Newport, Providence, Washington.

Fig. 6. *P. glaucus,* male. August, 1992. Middletown, Newport Co., R.I. *Leg.* Mark Schenk. Dorsal view.

Fig. 7. *P. glaucus*, male. Same data as Fig. 6. Ventral view.

Fig. 8. *P. glaucus,* female. July 17, 2006. West Glocester, Providence Co., R.I. *Leg.* Harry Pavulaan. Dorsal view.

Fig. 9. *P. glaucus*, female. Same data as Fig. 8. Ventral view.

Fig. 10. Neotype, female, *P. glaucus.* Black form "nigra" (Scott, 1981). September 10, 2000. Sandbridge, Virginia Beach, VA. *Leg.* Harry Pavulaan. Dorsal view.

Fig. 11. Neotype, female, *P. glaucus.* Black form "nigra". Same data as Fig. 10. Ventral view.

Fig. 12. *P. glaucus*, spring form, male. June 3, 1984. Great Swamp Management Area, West Kingston, Washington Co., R.I. *Leg.* Harry Pavulaan. Dorsal view [abdomen removed for genome research].

Fig. 13. *P. glaucus*, spring form, male. Same data as Fig. 12. Ventral view.

Fig. 14. *P. glaucus*, spring form, female. June 3, 1983. West Greenwich, Kent Co., R.I. *Leg.* Harry Pavulaan. Dorsal view [abdomen removed for genome research].

Fig. 15. *P. glaucus*, spring form, female. Same data as Fig. 12. Ventral view.

Fig. 16. *P. glaucus*, spring form, female. Ex-ova from female of July 24, 2006. Foster Center, Providence Co. Em: Feb. 19, 2007 (in lab). *Leg.* Harry Pavulaan. Dorsal view.

Fig. 17. *P. glaucus*, spring form, female. Same data as Fig. 16. Ventral view.

Pterourus near-*canadensis* (Rothschild & Jordan, 1906)
Canadian Tiger Swallowtail

Status: It is unclear which spring "Tiger Swallowtail" individuals are actually attributable to *canadensis*. What makes this difficult is that some spring individuals of the Eastern Tiger Swallowtail are virtually identical to the Canadian Tiger Swallowtail and some early "New England Tiger Swallowtails" may be rather on the small side. See "Comments" below for further information on distinguishing *canadensis* from *glaucus*. *Canadensis* is reliably found in western Massachusetts and northwestern Connecticut. If *canadensis* does occur in Rhode Island (Figs. 18-21), it is apparently rare or very infrequent, and more likely a stray from regions further north.

Habitat: An inhabitant of virtually all forested habitats, though the species is better associated with the transition zone forest of northern New England, western Massachusetts and northern Connecticut.

Larval Hosts: In Rhode Island, a captive female oviposited on, and larvae fed and matured on Black Cherry (*Prunus serotina*). Also reported on the same host in Connecticut and Massachusetts for all members of the *glaucus* complex, thus making this host not a good measure for distinguishing species. The species feeds on hosts that are documented to be toxic to *glaucus* larvae, such as *Populus tremuloides* (Quaking Aspen) and *Betula papyrifera* (Paper Birch) but there are no actual documented reports for use of these hosts in southern New England. Both hosts are, in fact, quite common in Rhode Island.

Habits: Males patrol back and forth along forest roads and along watercourses. In the White Mountains of New Hampshire, *canadensis* is known to be exceedingly abundant, often found in "enormous numbers", such as "600-700 individuals" that were once observed along a damp roadside edge (Kiel, 2003). In southern New England, no such large aggregations have been reported.

Broods: One brood. **Confirmed early dates**: May 20 (Connecticut); June 4 (Massachusetts); May 8 (Rhode Island). **Confirmed late dates**: July 2 (Connecticut); June 4 (Massachusetts); June 3 (Rhode Island).

Distinguishing features and variation: The smallest of the Tiger Swallowtails (though rivalled by some dwarfed individuals of spring brood *glaucus*). Wingspan is given as "53-99 mm" in Canada (Layberry et al., 1998), though this likely reflects the smallest *P. canadensis arcticus*

(Skinner, 1906) and the largest of the "Mid-Summer Tiger Swallowtails". Ording (2008) measured the forewings of *canadensis* in Vermont, measuring 39-53 mm in length (averaging 45.1 mm), more applicable to southern New England *canadensis*. The Rhode Island specimens have an average wingspan of 70 mm. Several characters have been identified, which can be used for distinguishing *canadensis* from *glaucus*, but are not always reliable. The hindwing tends to be more angular (triangle-shaped) than in *glaucus* (Figs. 18-21, 37, 38). Dorsally and ventrally, the black edge along the inner margin of the hindwing, adjacent to the thorax, is wide while in *glaucus* it is narrow. In the females, the blue chevrons on the dorsal hindwing are subdued, whereas in *glaucus* the blue chevrons tend to be broad and generally form into a solid band. Ventral characters are most reliable: The yellow submarginal band of the forewing is formed into a solid band, which replaces the row of yellow spots in *glaucus*; the black line separating the yellow inner region of the hindwings from the blue submarginal chevrons is straight as opposed to scalloped in *glaucus*; the marginal chevrons of the hindwing tend to be rectangular in shape (technically tilted quadrilaterals), whereas in *glaucus* they form crescents; and the outer edge of the hindwing is more akin to a slanted staircase pattern whereas in *glaucus* it is strongly scalloped. However, a percentage of *glaucus* individuals of the spring brood may take on all the characters of *canadensis* and can only reliably be differentiated by experimenting with host acceptance and voltinism. Most importantly, there is no black female form in *canadensis*.

One reliable way to distinguish *canadensis* from either *glaucus* and the Mid-Summer Tiger Swallowtail is to examine the first instar larvae. The larvae of *canadensis* are black with three white transverse saddle marks on the back. It is not known if this larval character difference holds up with the other two species: the New England and Mid-Summer Tiger Swallowtails. Schmidt (2020) provides a comparison between *glaucus*, *canadensis* and the "Mid-summer Tiger Swallowtail" in which he illustrates how the male clasper scales of *canadensis* bear sparse black scales. While the male claspers of *glaucus*, "New England Tiger Swallowtail" and the "Mid-summer Tiger Swallowtail" are generally clear yellow, most males of the *glaucus* spring brood from regions as far south as the Carolinas appear to have variable clear-yellow or black-dusted claspers. This character difference is difficult to ascertain from internet and published images.

Comments: In a 1983 rearing experiment, a female tentatively identified as *canadensis* in Rhode Island was confined on *Prunus serotina*, on which she readily oviposited. Approximately 30 ova were deposited on leaves. The first instar larvae displayed the three saddle marks characteristic of northern *canadensis.* The larvae were reared under identical conditions to captive (ex-ova) *glaucus* larvae. The *canadensis* larvae produced diapausing pupae that did not produce a summer generation, while the *glaucus* immatures produced a late summer generation of typical summer form *glaucus*. Unfortunately, the *canadensis* chrysalids were not exposed to winter cold. Rather, they were kept in warm indoor conditions in hopes of forcing a false second brood. These desiccated without producing adults in 1984, despite misting.

A study by Scriber et al. (2002) indicated that summer maximum temperatures in the range of 30-36°C (86-97°F) over a period of four days were lethal to diapausing pupae of *canadensis.* Data from the Rhode Island Dept. of Environmental Management (accessed online, 2023) stated that interior portions of Rhode Island experienced an average of 8-10 days of high temperatures of 36°C (97°F) annually, with some summers experiencing as many as 20 or more such warm days. Scriber et al. (2002) concluded: "Natural temperature-induced stress on diapausing pupae prevents *canadensis* from extending range south." Interestingly, along the immediate coast, temperatures rarely ever exceed 90°F, due to the moderating effect of the ocean. This might account for records of *canadensis*-like specimens near the Rhode Island coast.

Distributional County Records: Confirmed photo or specimen records for this study. **Connecticut:** Litchfield, New Haven. **Massachusetts**: Berkshire [spring records throughout the remainder of Massachusetts appear to be confused with the "New England Tiger Swallowtail"]. **Rhode Island**: Kent, Washington.

Fig. 18. *Pterourus* "near-*canadensis*", male. June 3, 1984, Quidnick, Kent Co., R.I. *Leg.* Harry Pavulaan. Dorsal view [abdomen removed for genome research].

Fig. 19. *Pterourus* "near-*canadensis*", male. Same data as Fig. 18. Ventral view.

Fig. 20. *Pterourus* "near-*canadensis*", female. May 8, 1983, Coventry, Kent Co., R.I. *Leg.* Harry Pavulaan. Dorsal view [abdomen removed for genome research].

Fig. 21. *Pterourus* "near-*canadensis*", female. Same data as Fig.20. Ventral view.

***Pterourus bjorkae* Pavulaan, 2024**
New England Tiger Swallowtail
(new species)

ZooBank registration: urn:lsid:zoobank.org:act:5524CE5E-2146-4F91-A9AD-2E8EC1FE5BD7

Holotype and TL: A female holotype has been designated to represent this species (**Figs. 22-23**). This is due to the problem of differentiating males from other species within the *glaucus* species complex. Females are most distinct. The type locality is Great Swamp Management Area, West Kingston, Washington County, Rhode Island, May 15, 1990. An allotype male (**Figs. 24-25**) has been designated: Great Swamp Management Area, West Kingston, Washington County, Rhode Island, June 3, 1984. 12 male and 7 female paratypes are retained by the author. Many other paratypes in the collection of the late Alex Grkovich.

Status: Originally viewed as a possible distinct species during my 1983-1984 Rhode Island field surveys. Uncommon resident, though very widespread in occurrence. Generally, only observed as single individuals, less frequently only in very small numbers in Massachusetts. No population irruptions were ever observed or reported.

In many respects, *P. bjorkae* appears analogous to Appalachian *P. appalachiensis*, and has been referred to as *P.* "near-*appalachiensis*" by local butterfly observers for several years as of this writing. Intermediate characters between *glaucus* and *canadensis* lends to a hybrid origin for *appalachiensis* through introgression of characters during the last glacial maxima (Kunte, *et al*, 2011; Ording, 2008; Ording et al., 2009; Scriber & Ording, 2005). This very likely has occurred as well with *bjorkae.* It is possible that there is still hybridization occurring between this species and siblings *glaucus* and *canadensis*. However, this taxon does appear to be a stable, breeding population in southern New England. It also appears to replace *canadensis* in the southern New England springtime niche, though some *canadensis*-like individuals have been taken as far south as Rhode Island. On Long Island, N.Y., south of the Long Island Sound, I have taken many *bjorkae* specimens during the spring months, along with typical *glaucus*, but *canadensis*-like individuals are absent.

One consideration was to propose this as a new subspecies of *canadensis*. However, the presence of small, potential *canadensis*-like adults sympatric with the larger *bjorkae* in places like western Massachusetts, northern Connecticut and even Rhode Island, tentatively lends to species status. Much work remains to be done, to determine any relationship with *canadensis* populations to the north, to determine if they are allopatric (possibly with a hybrid zone), sympatric, or if *bjorkae* is a southern expression (subspecies) of *canadensis.*

Habitat: Primarily a resident of deciduous forest habitats, though adults are frequently found in urban and suburban habitats.

Larval Hosts: Black Cherry (*Prunus serotina*) is currently the only confirmed hostplant in southern New England. *Prunus virginiana* (Choke Cherry) is reported for the "Mid-Summer Tiger Swallowtail" in southern Ontario (Wang, 2017). Certainly, other hosts are used but require documentation based on rearing. It is not presently known if the larvae can eat *canadensis*-specific hosts such as *Betula* spp. (Birch) and *Populus tremuloides* (Quaking Aspen), or *glaucus*-specific hosts such as *Liriodendron tulipifera* (Tulip Tree).

Habits: This butterfly appears to be primarily a forest canopy dweller, much as is *P. appalachiensis* of the Appalachian Mountain region. Adults are mainly observed in rapid flight in forested habitat, coming down to nectar at numerous nectar sources such as *Syringa vulgaris* (Common Lilac) in the spring, and *Asclepias syriaca* (Common Milkweed) in late June. The species is not common, and generally only seen as single individuals near the southern coastal region, though they have occasionally been observed in small "puddle parties" in Massachusetts.

Broods: Apparently one brood. Obligate univoltine, corroborated by Hagen & Lederhouse (1985) for New York. Appearance of similar individuals in late summer confuses matters and requires extensive rearing to determine if hybridism influences voltinism. **Confirmed early dates**: April 30 (Connecticut); May 15 (Massachusetts); May 8 (Rhode Island). **Confirmed late dates**: June 12 (Connecticut); July 8 (Massachusetts); June 12 (Rhode Island). An overlap of flights with the "Mid-Summer Tiger Swallowtail" has not been documented in southern New England.

Distinguishing features and variation: The largest of the three spring-flying Tiger Swallowtails. Wingspan of measured specimens (N=19) is 75.2-92.1 mm (averaging 84.7 mm), with a forewing length of 43.0-55.3 mm (averaging 49.2 mm). Specimens of *bjorkae* in this study measured larger than Vermont *canadensis.* The females of *bjorkae* are most distinct [thus selection of a female specimen to serve as the holotype] (Figs. 22, 23, 26, 27, 34). Dorsally, the female individuals are readily differentiated from *glaucus* by the greatly reduced row of blue submarginal chevrons on the dorsal hindwing, never forming into a solid blue band. Examined specimens and photo images reveals fewer blue chevrons than in *canadensis* females. Some females nearly lack the submarginal blue chevrons, except always appearing in cells CuA2 and CuA1. This gives some females the appearance of the male phenotype. The interior of the dorsal hindwing is clear yellow and is never covered by the subtle blue wash of scales found in most *glaucus* females. Also, the female black form has not been documented.

Ventrally, the diagnostic submarginal yellow band on the forewing of *bjorkae* specimens is solid though the anterior portion of the band may be broken in many individuals. The hindwing is narrower and more angular than *glaucus*, being somewhat more similar to *canadensis* and *appalachiensis*, and is characterized by outer wing edge being more "stair-stepped" and not scalloped as in *glaucus*. Similarly, the postmedian boundary between interior yellow ground color and the submarginal row of blue chevrons forms a straight black ribbon. The hindwing marginal lunules are shaped more like a row of slanted rectangles, though the shape is variable. In some individuals these marginal lunules may have the look of crescents as in *glaucus*. Also, the black band along the inner (anal) margin is wide as in *canadensis*.

The dorsum of *bjorkae* males (Fig. 24) is intermediate between *glaucus* and *canadensis* males and also very similar to males of the other New England "Tiger Swallowtail" species, and can easily be misidentified. *P. bjorkae* males differ from *P. appalachiensis* and *canadensis* by having more rounded wings and a broader black area on the outer portion of the dorsal hindwing; whereas the females differ by having reduced dorsal blue hindwing chevrons and a broader black outer portion of the hindwings. Some females appear male-like. *P. bjorkae* is also larger than *canadensis.*

Wang (2017) illustrates a first instar "hybrid" larva from southern Ontario that is intermediate between first instar larvae of glaucus and *canadensis*, in which the white saddle mark of both (parent) species is present but the posterior and anterior bands typical of *canadensis* first instar larvae are reduced. Future studies would help document that this is consistent for *bjorkae* in New England.

Comments: In 1984-1985 and 2006-2007 rearing experiments, females tentatively identified as *bjorkae* were confined on *Prunus serotina*, on which they readily oviposited. Approximately 10 ovae were deposited on leaves during each of the two years. The resultant larvae were reared indoors under lab conditions. The larvae produced hibernal-diapausing pupae. In the 2006-2007 experiment, one resultant female (Figs. 26-27) emerged that clearly appears to be intermediate between *bjorkae* and *glaucus*, except that she has a near absence of the dorsal hindwing blue chevrons, more typical of *bjorkae*.

Distributional County Records: Confirmed photo or specimen records for this study. **Connecticut**: Fairfield, Hartford, Litchfield, Middlesex, New Haven, New London, Tolland, Windham. **Massachusetts**: Bristol, Essex, Hampden, Hampshire, Middlesex, Nantucket. Norfolk, Plymouth, Worcester. **Rhode Island**: Kent, Providence, Washington.

Fig. 22. Holotype, female, *P. bjorkae.* May 15, 1990. Great Swamp Management Area, West Kingston, Washington Co., R.I. *Leg.* Harry Pavulaan. Dorsal view.

Fig. 23. Holotype, female, *P. bjorkae.* Same data as Fig. 22. Ventral view.

Fig. 24. Allotype, male, *P. bjorkae.* June 3, 1984. Great Swamp Management Area, West Kingston, Washington Co., R.I. *Leg.* Harry Pavulaan. Dorsal view.

Fig. 25. Allotype, male, *P. bjorkae.* Same data as Fig. 24. Ventral view.

Fig. 26. Paratype, female, *P. bjorkae.* Ex-ova from female of May 1996. West Kingston, Washington Co., R.I. Em: Feb. 19, 1997 (in lab). *Leg.* Harry Pavulaan. Dorsal view.

Fig. 27. Paratype, female, *P. bjorkae.* Same data as Fig. 26. Ventral view.

Etymology: This butterfly is named in honor of Icelandic singer, songwriter, composer, record producer, music and fashion collaborator, actress, disk jockey, environmental activist, and personal inspiration, Björk Guðmundsdóttir (**Fig. 28**).

Fig. 28. Björk Guðmundsdóttir (1995)
Photo courtesy Eric Mulet.

Pterourus late-flight hybrid(?) species
"Mid-Summer Tiger Swallowtail"

Status: The flight period in Massachusetts (Fig. 3) indicates a strong bimodal flight, and the summer peak in that state is well-defined, though total numbers are inflated by *glaucus* in summer. In Rhode Island (Fig. 4), the bimodal pattern is evident but masked by greater numbers of *glaucus*. In Connecticut (Fig. 5), the bimodal pattern is inflated by the presence of both the "Mid-Summer Tiger Swallowtail" and *glaucus*. Ording (2008) studied the "early flight" (*canadensis*) and "late flight" hybrid in Vermont and concluded the late flight (Mid-Summer Tiger Swallowtail) may be considered an incipient species, with morphological characteristics "virtually identical to *P. appalachiensis*". Ording also suggested: "The LF is now either geographically isolated or temporally isolated from both of the parental populations". My observations have demonstrated that this concept falls apart in southern New England, where four taxa occur.

Habitat: Primarily a resident of deciduous forest habitats, though adults are frequently found in urban and suburban habitats.

Larval Hosts: The hostplant has not yet been confirmed in southern New England. These require documentation based on rearing. First instar larvae of intermediate characters (between *glaucus* and *canadensis*) have been documented on *P. serotina* in July.

Habits: This butterfly appears to be primarily a forest canopy dweller, much as is *P. appalachiensis* of the Appalachian Mountain region. Adults are mainly observed in rapid flight in forested habitat, coming down to nectar at numerous nectar sources such as *Buddleia* sp. (Butterfly Bush) in gardens. The species is not common, and generally only seen as single individuals or in very small numbers.

Broods: Apparently one brood. Obligate univoltine. Sympatric flight of *glaucus* in late summer confuses matters and requires extensive rearing to determine if hybridism influences voltinism. **Confirmed early dates**: July 5 (Connecticut); July 10 (Massachusetts); July 6 (Rhode

Island). **Confirmed late dates**: September 9 (Connecticut); August 21 (Massachusetts); September 12 (Rhode Island).

Distinguishing features and variation: Adults are large, matching *glaucus* in size. Wingspan is given as 5.5" (139 mm) maximum in Connecticut (O'Donnell et al., 2007). Ording (2008) measured the forewings of Vermont specimens and determined the wings to average 50.60-51.42 mm in length. The females of the "Mid-Summer Tiger Swallowtail" are most distinct [thus it is recommended that the selection of a female specimen should serve as a holotype]. Dorsally, the female individuals are readily differentiated from *glaucus* by the greatly reduced row of blue submarginal chevrons on the dorsal hindwing. In many specimens, the blue chevrons are nearly absent, except always appearing in cells CuA2 and CuA1. The interior of the dorsal hindwing is clear yellow and is never covered by the subtle blue wash of scales found in most *glaucus* females. Also, the female black form has not been documented. In all other respects (i.e.: wing shape, extent of bands, shape of marginal crescents) the dorsal side is nearly identical to *glaucus* females.

Ventrally, the diagnostic submarginal yellow band on the forewing of the "Mid-Summer Tiger Swallowtail" is solid, though the anterior portion of the band may be broken in many individuals. The postmedian boundary between interior yellow ground color and the submarginal row of blue chevrons forms a slightly scalloped but nearly straight black ribbon. The hindwing marginal lunules are shaped more like crescents as in *glaucus*, though the shape is variable. Also, the black band along the inner (anal) margin is narrow as in *glaucus*.

The dorsum of "Mid-Summer Tiger Swallowtail" males (Figs. 31, 39) is nearly identical to *glaucus* males and can easily be misidentified.

Wang (2017) illustrates a first instar "hybrid" larva from southern Ontario that is intermediate between first instar larvae of glaucus and *canadensis*, in which the white saddle mark of both (parent) species is present but the posterior and anterior bands typical of *canadensis* first instar larvae are reduced. First instar larvae collected in Massachusetts in July possessed two saddle marks: the large middle saddle mark and a reduced anterior saddle. Future studies would help document that this is consistent for the Mid-Summer Tiger Swallowtail in New England.

Comments: This taxon is currently under study in Canada (Wang, 2017; Schmidt, 2020; Ontario Butterfly Atlas, 2020). It is theorized that the "Mid-Summer Tiger Swallowtail" could be undergoing early stages of speciation in sympatry with *glaucus* in the historic "hybrid zone". One possibility is that secondary contact since the last glacial maxima, over a broad area, may indicate a previous, incomplete early stage toward speciation. While it is apparently more stable as a species-level taxon in Ontario (Schmidt, 2020), in New England it appears that there may be rampant hybridization with fully sympatric *glaucus* as indicated by a great many intermediate summer-brood individuals that cannot be reliably assigned to either.

Distributional County Records: Confirmed photo or specimen records for this study. **Connecticut**: Fairfield, Hartford, New London. **Massachusetts**: Bristol, Essex, Hampshire, Middlesex, Worcester. **Rhode Island**: Providence, Washington.

Fig. 29. *Pterourus* (sp.) "Mid-Summer Tiger Swallowtail", female. August 1, 1984, Great Swamp Management Area, West Kingston, Washington Co., R.I. *Leg.* Harry Pavulaan. Dorsal view.

Fig. 30. *Pterourus* (sp.) "Mid-Summer Tiger Swallowtail", female. Same data as Fig. 29. Ventral view.

Fig. 31. *Pterourus* (sp.) "Mid-Summer Tiger Swallowtail", male. July 12, 2008, Newbury, Essex Co., MA. *Leg.* Matt Arey. Dorsal view.

Fig. 32. *Pterourus* (sp.) "Mid-Summer Tiger Swallowtail", male. Same data as Fig. 31. Ventral view.

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APPENDIX A

Visual comparison of *glaucus, bjorkae, canadensis* and "Mid-summer Tiger Swallowtail" (split views).

Fig. 33. Allotype (male), *Pterourus bjorkae.* June 3, 1984, West Kingston, Washington Co., R.I. Dorsal (left), ventral (right).

Fig. 34. Holotype (female), *Pterourus bjorkae.* May 15, 1990, West Kingston, Washington Co., R.I. Dorsal (left), ventral (right).

Fig. 35. Neotype (male), *Papilio alcidamas* Cramer 1775. September 10, 2000, Sandbridge, Virginia Beach, VA. Topotype of *Pterourus glaucus* Linnaeus 1758 (Pavulaan & Wright, 2002) (with same data). Dorsal (left), ventral (right).

Fig. 36. Topotype (female), *Pterourus glaucus* Cramer, 1775. September 10, 2000, Sandbridge, Virginia Beach,VA. Dorsal (left), ventral (right). Yellow form.

Fig. 37. Holotype (male), *Papilio canadensis* Rothschild & Jordan, 1906. June 25, 1906, St. John's, Newfoundland. Dorsal (left), ventral (right). Photo courtesy of Norbert Kondla.

Fig. 38. *Pterourus canadensis* (female). July 5, 2009, Mount Uniacke, Hants Co., Nova Scotia. Dorsal (left), Ventral (right).

Fig. 39. *Pterourus* (sp.) "Mid-Summer Tiger Swallowtail" (male). July 12, 2008, Newbury, Essex Co., MA. Dorsal (left), ventral (right).

Fig. 40. *Pterourus* (sp.) "Mid-Summer Tiger Swallowtail (female). August 1, 1984, Great Swamp Management Area, West Kingston, R.I. Dorsal (left), ventral (right).

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