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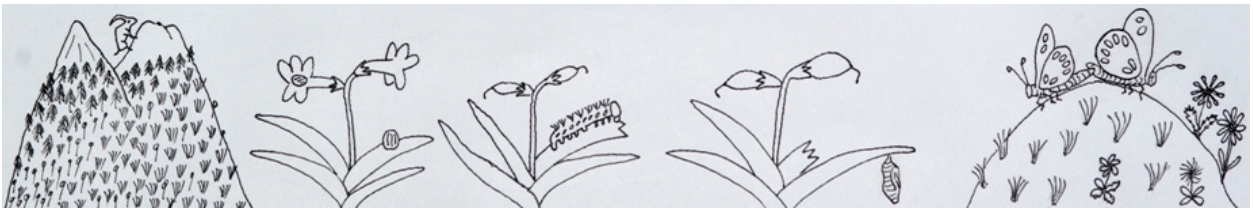

# IDENTIFICATION OF *PHYCIODES DIMINUTOR*, *P. COCYTA*, AND *P. THAROS* IN NORTHEASTERN U.S. (NYMPHALIDAE)

by
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Abstract. This issue of Papilio (New Series) consists of three studies on the identification of the closely-related species *Phyciodes diminutor diminutor* Scott, *P. cocyta selenis* (W. Kirby)and *P. tharos tharos (*Drury), from Vermont, Ohio, and Michigan (studies labeled A, B, and C below). Identification problems have hindered the study of these butterflies in the northeastern U.S., and misidentifications have even occurred in recent DNA studies. Difficulties in distinguishing *diminutor* & *selenis*, and their status, are discussed. Vermont contains all three taxa in this group. *P. tharos* has two generations and occurs in southern and central Vermont, north to Woodsville on the Connecticut River on the E edge of Vermont, and occurs also on North and South Hero Islands in Lake Champlain in extreme NW Vermont. *P. cocyta* has one generation and evidently occurs in the cooler areas throughout Vermont except in the two southern counties Bennington and Windham. *P. diminutor* has two generations and evidently occurs throughout Vermont if it belongs to a separate species *P. diminutor* as studies elsewhere suggest. Michigan has all three species, while northern Ohio (including Lucas Co.) has *P. tharos* and *P. diminutor*. Few of the specimens of *P. cocyta*, *P. tharos*, and *P. batesii* used in the mtDNA study of Proshek & Houghton (2006) were misidentified (among all specimens examined, a few "*tharos*" and "*cocyta*" are *P. diminutor*, some "*batesii*" females from one site are *P. cocyta*, and all "*cocyta*" from S Mich. are *P. diminutor*). mtDNA is not usable to identify any of these species. The proper future research plan is described, which includes rearing numerous families found on wild identified hostplants from localities with multiple taxa.

# A. *PHYCIODES* FROM VERMONT, BASED ON SPECIMENS AND PHOTOGRAPHS TAKEN FOR THE VERMONT BUTTERFLY SURVEY

(by James A. Scott, in cooperation with Vermont Butterfly Survey coordinator Kent P. McFarland, formerly of Vermont Center for Ecostudies, P.O. Box 420, Norwich, VT 05055, http://www.vtecostudies.org/)

Introduction. Numerous people collected butterflies throughout Vermont from 2002 to 2007, in order to document the spatial and temporal distribution and status of the butterfly fauna of that state. 798 specimens or photos of Vermont *Phyciodes* were sent for identification by Kent McFarland to Scott, who has recently revised the systematics and taxonomy of these butterflies (Scott 1986, 1994, 1998, 2006). Scott identified those specimens/photographs that could be reliably identified, enough individuals to form a good summary of the species occurring in Vermont and their distribution.

Identification difficulties. Adults of the *P. tharos*-group—especially single wild-caught adults—often cannot be identified. Most photographs could not be confidently identified because key characteristics were not adequately shown (the best identification traits of these butterflies involve the color of the scaleless area on one side of the antenna club, the extent of black line across the orange area on dorsal hindwing, the size and color of the brown patch on ventral hindwing margin, wing size, and degree of melanism on dorsal forewing of females). Photographed adults could usually be identified if the upperside and antenna club were clearly visible, but photos showing only underside or photos of mating pairs could not be identified. Most females could not be identified because *Phyciodes* females are less different between species than are males. Many males could not be identified, because the characters of *Phyciodes tharos* and the *P. cocyta* (Cramer) group (including *P. cocyta selenis* and *P. diminutor diminutor*) vary considerably and the species overlap in the variation of all of those characters, so that the only specimens that can be confidently identified are those that contain most of the "key" characters in a state that is most different from the state possessed by most of the typical or most-different individuals of the other species. Also, the specimens were collected by volunteers, so many specimens were somewhat broken, with antennae and the key antenna club nudum character missing, so those could not be confidently identified. The best way to study *Phyciodes* is to rear a family (a cluster of eggs or small larvae produced from one mother) to adulthood, in which case the traits of larvae and pupae and adults of the whole reared family always (in Scott's experience) allow a confident identification. However, a large number of specimens were collected and photographed, resulting in an adequate number of confidently-identifiable specimens, allowing some confident conclusions to be made. The specimens were either identified as *P. tharos* or *P. cocyta*, because adults of *P. cocyta* and *P. diminutor* are basically similar except for size, and those taxa are only distinguished in Vermont by inferences involving size and flight time, as noted below. Each specimen was either confidently identified as *P. tharos* or *P. cocyta* (although even some of these could possibly be incorrectly identified), or was given one of those names followed by a ? (implying less certainty of identification), or was not identified and was merely stated to be *Phyciodes* sp. The conclusions drawn from this study of the Vermont butterflies are based on the confidently-identified specimens, and a few range extensions etc. based only on dubiously-identified specimens are ignored because of the possibility of misidentification. Most of the unidentified specimens are likely to be *P. cocyta* (*P.*

*c. selenis* or *P. d. diminutor*), because *P. cocyta* dominates the confidently-identified specimens, and *P. tharos* is much less frequently found in Vermont. In areas of Vermont where *P. tharos* is evidently absent (Franklin, Lamoille, Washington, Orange, Orleans, Essex Cos., and all but the southernmost part of Caledonia Co.), all the unidentified specimens are probably *P. cocyta* also.

Curatorial Notes. Data for each specimen is on a hand-written 3x5" data card, and most of that data is on an Excel database. Scott made preliminary labels for all mounted specimens in order to study them, which will be replaced by better labels on high-quality card paper later. Scott placed identification labels on all mounted specimens. The identification (species identity and sex) of papered specimens were written on a printed copy of the Excel spreadsheet. Each specimen was identified as *tharos*, *tharos*?, *cocyta*, or *cocyta*?, or merely as "sp." (meaning it could not be identified), and the sex was noted. Forewing lengths were measured (to the nearest whole mm or .5 mm) using a small transparent plastic ruler, and written on the left of the printed Excel spreadsheet. Various notes on the antenna club nudum color, the extent of black line across dorsal hindwing, the ventral hindwing brown patch size, overall size, presence of melanism on dorsal forewing of females, and presence of spring form *marcia* (ventral hindwing with added brown and white markings) were often written in scribbled (difficult to read) handwriting on the printed Excel spreadsheet. Four non-*Phyciodes* were found, including three *Chlosyne harrisii* (two specimens and one photo), and one female *Poanes hobomok*, as noted below. The specimen boxes arrived with about 8 abdomens plus other parts broken off and loose in boxes, so Scott examined the broken surfaces of abdomens and thoraxes with a microscope and was able to match their ragged margins, so Scott glued abdomens onto the thoraxes from which they departed. Various body parts especially antennae were found in envelopes and studied along with the main body and wings, and if loose antennae were found in envelopes from which the specimen had already been mounted, those antennae were glued onto those mounted specimens. Several dozen specimens were kept by Scott as representatives of the variation in Vermont, and those have the letters "JAS" on the left edge of the printed Excel spreadsheet in the SP=spread column at the head of that specimen's entry.

Some mistakes/anomalies were found in the entries in the Excel spreadsheet of specimen/photograph data, most of which should be corrected, as follows:
1,199 is *Chlosyne harrisii* photo.
2,245 is both specimen and also a photo
3,369 is *Chlosyne harrisii* specimen (mounted).
3,912 is a photo, not a specimen.
6,131 is a specimen, not a photo.
6,155 is a photograph, not a specimen.
6,158 is a photograph, not a specimen.
9,425 is three photos, not one photo.
9,766 photo is a Sphingidae moth larva.
10,224 is a specimen, not a photo.
10,369 is a specimen, not a photo.
10,981 is not mounted (delete SP), it is a photo.
11,874 is a specimen, not net-release.
12,115 is okay, evidently it IS net-release (the only one).
12,115 lacks a data card, which is missing.
14,285 gives a date of April 8, which is very early so is probably a mistake.
15,094 is a specimen, not net-release.

15,605 envelope also contained a female specimen of *Poanes hobomok* (Hesperiidae), which I transferred to its own envelope and added the data from envelope 15,605 and placed its envelope at the head of the data envelopes.
15,607 was surely collected on June 16, 2007, based on the identical information and handwriting on its data card compared to that on data card 15,609.
15,844 is *Chlosyne harrisii* specimen (mounted).
16,402 has no county listed (just "Morrisville-5 map"), perhaps the exact location is unknown.
18,508 is a specimen, not net-release.
22,509 is a specimen, not a photo.
23,132 is a photo, not net-release.

Results (Figs 3-4 show some adults)

*Phyciodes tharos tharos* traits and range. *P. tharos tharos* is generally rather small (Table 1 shows that Vermont males average 15.8 mm forewing length), the dorsal hindwing usually has a conspicuous line across the orange area in the middle of the wing, the scaleless area on the antenna club (the nudum) is usually black, and the brown patch on the margin of ventral hindwing is usually rather blackish-brown and narrow (in females, the nudum is less-often black, and the brown patch is wider).

*P. tharos tharos* is present throughout southern Vermont, at least in the lowlands, including Bennington, Windham, Rutland, & Windsor Cos., is also widespread in west-central Vt. in Addison Co., and then extends northward along the W edge of Vt. next to Lake Champlain to the Burlington area in Chittenden Co., then occurs in NW Vt. only on South Hero Island and North Hero Island in Grand Isle Co. (*P. cocyta* also occurs on these islands). On the east side of Vt., *tharos* extends north of Windsor Co. only along the Connecticut River barely to Woodsville at the southern tip of Caledonia Co. There are no confident records from Orange Co. as yet, but *tharos* obviously must occur along the Connecticut River in Orange Co. in order to reach Woodsville. Overall, *P. tharos* is much less widespread in Vermont than the *P. cocyta*-group, though it may be common where it occurs. *P. tharos* occurs at slightly lower altitudes than *P.* "*cocyta*"in Vermont (Table 2).

Flight times of the confidently-identified and probable *P. tharos* were charted (Fig. 1). *P. tharos* has two generations in Vermont, mostly M May-M June and L July-M Sept. in southern Vermont (in Bennington & Windham Cos., where there may be a partial 3rd gen. in some years), although the first flight is a bit later L May-E July and L July-M Sept. in Windsor and Rutland Cos. There are fewer records northward but the two generations there evidently fly at the same time as those in Windsor & Rutland Cos.

*Phyciodes cocyta selenis* and *P. diminutor diminutor* traits and range. These species are generally larger than *tharos*, the dorsal hindwing usually has a large orange space in the middle of the wing (without a line crossing it), the scaleless area of the antenna club (the nudum) is usually orange, and the brown patch on the margin of ventral hindwing is usually fairly wide (nearly as wide as long)(in females, the nudum is often brown, and the brown patch is wide).

*P. cocyta selenis* is known to be a separate species from *P. tharos*, mostly based on sympatry of the two species over large regions of North America, from Colorado north to Canada and in the Appalachian Mts. *P. diminutor diminutor* is known to be a separate species from *P. tharos*, as they are sympatric in southern Minnesota, southern Ontario, northern Ohio, and evidently also in Vermont and Pennsylvania. Wahlberg et al. (2003) found that the mtDNA showed *tharos* to

be a distinct species from the *P. cocyta*-group, and found that *P. tharos* and *P. diminutor* could be distinguished by mtDNA where they are sympatric in southern Minnesota.

The two *P. cocyta* group taxa are much more common in Vermont than *P. tharos*, and occur throughout the state in two evident species (which are still considered to be subspecies by most people who lack knowledge of *Phyciodes*, owing to the still-primitive nature of the research on eastern U.S. *Phyciodes*, as noted below). Flight times were charted for the confidently-identified specimens (Fig. 2). In Bennington and Windham Counties, there are evidently two generations every year, mostly in M May-M June and L July-M Sept., and evidently this butterfly is the slightly-smaller *P. diminutor diminutor* which always has two generations and is known to occur in southern Minnesota, NE Iowa, northern Ohio, southern and eastern Ontario, and northern New York, and now Vermont (the two-generation populations in Pennsylvania, Va., W.Va., and N.C.-Ga. are also presumed to be *P. diminutor* ssp.). (Table 1 shows that forewing length of male *diminutor* is 16.5 mm in the second generation and is a little larger in the first generation probably nearly 17 mm). Farther north in Vermont, an obvious excess of records occurs from M June-E July compared to L July-Sept. records (Fig. 2), which suggests that the slightly-larger single-generation butterfly *Phyciodes cocyta selenis* (which has a single generation flying M June-E July) is common there (but probably more restricted in distribution to colder areas) and flies along with *P. d. diminutor*. (*P. cocyta selenis* males have forewing length a mm or so larger than *P. d. diminutor*, so the combination of the larger *selenis* males and the smaller *diminutor* males in the "*P. cocyta* group" in Table 1 makes the average larger, 17.2 forewing length.) In all the counties north of Bennington-Windham Cos., there are still many records from M July-M Sept., suggesting that *P. diminutor diminutor* also occurs there in two generations June-E July and L July-E Sept. Because those late-season records of "*P. cocyta*-group"—which seem to be *P. d. diminutor*--occur throughout Vermont, it seems that *P. d. diminutor* occurs throughout Vermont and has two generations everywhere. *P. cocyta selenis* has just one generation mostly M June-E July (some fly June-M July), and this insect evidently occurs throughout central and northern Vermont, south at least to Rutland and Windsor Cos. It is difficult to state more specifically where *P. c. selenis* occurs in this area, because the single generation of *P. c. selenis* mostly overlaps the second half of the first generation of *P. d. diminutor*, and adults are similar (*selenis* averages a little larger, but adults of all these *Phyciodes* vary somewhat in size), so a given specimen might be one or the other species. If some localities have been well studied in Vermont, it may be possible to determine which species flies there (for instance some localities may have just one generation, indicating that only *P. c. selenis* occurs there--and some localities might have the first generation and the second generation equally common, which would suggest that only *P. d. diminutor* occurs there). Further examination of the localities and flight dates of the confidently-identified specimens will be necessary to pinpoint these ranges further (the mountains running down the middle of the state might have mostly *P. c. selenis*, the lowlands mostly *P. d. diminutor*, however the whole state of Vermont is somewhat mountainous and there aren't many "lowlands" except along the major rivers.). An examination of the records suggests that the second-generation individuals occur throughout Vermont, thus *P. d. diminutor* evidently occurs throughout Vermont. Small adults occur throughout Vermont also, again suggesting that *P. d. diminutor* occurs throughout Vermont. Somewhat larger adults occur frequently in Rutland, Washington, Lamoille, and Franklin Cos. at least.

Scott attempted to distinguish Vermont *P. cocyta selenis* from *P. diminutor diminutor* by measuring the forewing length of all the *P. tharos* and "*P. cocyta*-group" butterflies from Vermont, because *selenis* is known to be larger than *diminutor*. The results (average forewing

length in mm) are presented in Figs. 1 and 2 and summarized in Table 1. The table indicates that *P. tharos* is the smallest, and adults of its second generation are not significantly smaller than adults of the first generation (males are nearly identical in size, and females decrease in size in the 2nd generation, though females are less-reliably identified than males). Similarly, *P. diminutor diminutor* in extreme southern Vermont (Bennington & Windham Counties) are not smaller in the second generation than in the first (Table 1), although both sexes are a little larger than *P. tharos*. *P. cocyta selenis* is known to be larger than *P. diminutor diminutor*, based on butterflies studied in Ontario and Minnesota etc., and it always has just one generation (for instance 2nd generation adults never occur in Colorado)(except the probable synonym *pascoensis* Wright from Washington state has two generations, though it has not been adequately studied), so the larger size of the "*P. cocyta*-group" butterflies in the first generation versus the second generation (Table 1) seems to be consistent with the hypothesis that the first generation of "*P. cocyta*-group" butterflies in most of Vermont (except the southernmost counties of Bennington and Windham) represents an artificial mixture of two species, the larger single-generation *P. cocyta selenis* and the smaller *P. diminutor diminutor*, while the second generation of "*P. cocyta*-group" butterflies in the same area of most of Vermont is solely the second-generation of the smaller *P. diminutor diminutor*. (If two species are combined in the first generation in most of Vermont, the standard deviation of size should be larger in this area; however the presumed small numbers of *diminutor* in the 1st generation evidently make this effect too small to notice.)

To further study this hypothesis, the relationship between altitude and forewing length was studied, on the grounds that *P. cocyta selenis* is known to be larger and more boreal than *P. diminutor diminutor* which is smaller and more southern in distribution, so that specimens caught at higher altitude would be more likely to be the larger *P. c. selenis*, and those at low altitude would be more likely to be the smaller *P. d. diminutor*, so that wing length should increase with altitude. Table 2 charts the average and median altitude found for specimens having the measured wing lengths. There does not seem to be much change of forewing length with altitude, considering that there is great variation in the altitudes recorded for each wing length, and there does not seem to be a significant change with altitude. Also, the frequency of specimens found that possess each wing length (the sample sizes noted after each mean in Table 2) seem to fit reasonably a single bell shaped curve (Normal Distribution) of forewing length, which fits the hypothesis that there is just a single species of "*P. cocyta*" rather than two species (although the two presumed species *P. cocyta selenis* & *P. d. diminutor* are not very different in forewing length according to Table 1, so the sum of their wing length distributions would probably still look like a single bell-shaped normal distribution).

A more sophisticated analysis would add altitudes for specimens lacking it, would be a multivariate analysis, would assign "yearly degree days" to each site based on interpolating data gathered by weather stations in order to compare those to wing length and flight time, and would assign many or most of the unidentified specimens to *P. cocyta* if they came from areas where *P. tharos* does not occur (this would greatly increase the sample size of specimens available for study). Most specimen data cards have latitude and longitude, so a computer could map the records using that GIS data and the maps might show useful patterns of distribution. Local knowledge of Vermont would help, because Vermont is rather hilly all over the state and so the differences in climate between local sites of differing altitude and slope and aspect (N- or E- or W- or S- facing, etc.) are likely to be almost as great or greater than the differences between widely-separated localities within the state.

The hypothesis that Vermont "*P. cocyta*" actually consists of two species instead of one deserves further discussion, because those two butterflies evidently occur more widely in southeastern Canada and northeastern United States, south evidently to Pennsylvania and Virginia, so that hypothesis must be considered by everyone studying these butterflies in NE U.S. and adjacent Canada. Scott has personally reared these butterflies only from southern Minnesota westward, and has not done needed field work or rearing in Vermont or vicinity. A full study of them will require selecting critical locations and finding eggs and small larvae on hostplants and identifying the hosts and rearing those eggs & larvae to adults.

The alternative hypothesis is that there is just one species of "*P. cocyta"* in Vermont, which always has two generations in Bennington-Windham Cos. (where they would be called *P. cocyta diminutor* under this hypothesis), and usually has one generation in central and northern Vt. (where they would be called *P. cocyta selenis*), and has more-intermediate voltinism in Rutland-Windsor Cos. That taxonomic treatment fits the voltinism changes found from south to north in Vermont plotted in Fig. 2. Based only on the current Vermont data, the suggestion that there are two species of "*P. cocyta*" in Vermont cannot be proven, so the names given in this paragraph are the only ones that can be operationally applied to the specimens at this time.

However, previous research elsewhere suggests that there are evidently two species *P. cocyta selenis* and *P. diminutor diminutor* instead of one: Those two species were found to be sympatric in eastern Ontario (*selenis* in wetlands, *diminutor* on a limestone plateau) and northern New York (*selenis* in wetlands, *diminutor* on drier scrubby pastures) by Paul Catling (Catling 1997a, b, and see Scott 1998) and sympatric in S Ontario by Alan Wormington (see Gatrelle 2004). Also, in Pennsylvania Charles Oliver (references in Scott 1994) found that there are some populations that have several generations (which Scott assumes are *diminutor,* and David M. Wright has confirmed [pers. comm.] based on examination of Oliver's "type B" specimens in Yale Univ.), while other populations have just one-generation (which Scott assumes are *selenis*, and those extend southward to the one-generation populations evidently of *selenis* in West Virginia that were found by Paul A. Opler (pers. comm.) and Thomas Allen [Allen 1997])(the subspecies name *marcia* Edwards is available for these one-generation W.Va. butterflies, Gatrelle 2004). The larger ssp. *P. diminutor incognitus* Gatrelle has two generations in North Carolina and Georgia (research by Ronald Gatrelle 2004), and Scott (2006) assigned *incognitus* to *P. diminutor* because of its bivoltinism and because it belongs in the *P. cocyta*-group and not with *tharos*. *P. d. incognitus* evidently occurs in the Pocono Mts. of NE Pennsylvania (David M. Wright, see Scott 2006). Gibson & McInnis (~2007) since found *incognitus* in Rowan Co. Kentucky in May, where it presumably also has two generations. For a summary of the most recent research on these *Phyciodes*, see Scott (2006).

The electrophoresis findings of Porter & Mueller (1998) are somewhat equivocal in the matter. They suggested that the northern Michigan *P. cocyta* [*P. cocyta selenis*] be considered a subspecies of the southern Michigan & northern Ohio butterflies [which they misidentified as *P. tharos*]. However, Scott (2006) later examined all of their specimens and identified them all as *P.* "*cocyta*" group, not *tharos*; actually their N Mich. samples are *P. cocyta selenis*, but all their "*tharos*" from S Michigan and N Ohio are *P. diminutor diminutor*. They found gene frequency differences in glutamic-oxaloacetic transaminase (GOT-1)(locus E was greatly dominant in N Ohio and S Mich., while locus C was a little more frequent than E in N Mich.) and malate dehydrogenase (MDH-1)(locus C was dominant in frequency in N Ohio, .while locus B was highly dominant in N. Mich., although C was just slightly more frequent than locus B in S Mich. thus was intermediate). They suggested that these differences could be maintained by partial

genetic isolation and a small introgression rate, and that the two taxa can be considered to be subspecies "unless further research turns up evidence of genetic isolation". The discovery of sympatry of these taxa in eastern Ontario and northern New York by Paul Catling (Catling 1997a, b), and in Ontario by Alan Wormington, can be considered to provide that evidence of genetic isolation, so *selenis* and *diminutor* can also be considered to be separate species based on the electrophoretic evidence. It is doubtful that conclusions based on electrophoresis alone should be considered definitive in assigning species status, and the S Michigan sample was intermediate between the N Michigan and N Ohio butterflies in electrophoresis. But other taxa in the *P. tharos*-group seem to introgress a little (*P. cocyta* has evidently taken some genes from *P. tharos*, Wahlberg et al. 2003; *P. batesii anasazi* Scott has taken genes from *P. cocyta selenis*, Scott 1998; and *P. diminutor incognitus* has taken mtDNA from *P. tharos*, Scott 2006), so it seems reasonable to consider *P. diminutor diminutor* and *P. cocyta selenis* to be separate species that have introgressed somewhat. (Note: Porter & Mueller p. 184 wrote that the extent of the black line on dorsal hindwing (between median and postmedian orange bands) was influenced by photoperiod according to C. Oliver, but Oliver actually did not mention the upperside, Oliver showed that the ventral hindwing is influenced by photoperiod.)

At any rate, although more research is needed and the Vermont data does not show it, Scott currently considers that Vermont has three species of these *Phyciodes*: 1) the clearly demonstrated *P. tharos tharos* which flies in two generations in the southern 2/3 of Vermont and northward to NW Vermont on islands warmed by Lake Champlain; 2) *P. cocyta selenis* which occurs in one generation over the northern ¾ of Vermont (probably in the cooler sites such as cooler slopes etc.); 3) and *P. diminutor diminutor* which evidently occurs throughout Vermont in two generations, perhaps preferably in warmer sites.

Plan for future research. More detailed collections and research in Vermont should indicate whether there are localities where just the single-generation *P. cocyta selenis* occurs, and whether there are localities in central or northern Vermont where only the two-generation *P. diminutor diminutor* occurs. Ideally, someone should pursue a detailed study of eastern North American *Phyciodes*. A survey should be done to find sites where several taxa are thought to occur together, a search of the asters there should be done to collect eggs and young larvae of all the *Phyciodes* present there (young larvae are easiest to find because they skeletonize the underside thus devastate their aster leaf making it very visible, and 1st & 2nd stage larvae should be found and reared because 3rd stage larvae may be already programmed by photoperiod to diapause), those aster hosts should be identified, each family of immatures should be reared, notes on the young-larval silk webs should be recorded, photos should be made of older larvae and pupae and some should be pickled, and the resulting reared adults should be examined for antenna/wing phenotype and identified (and ideally tested using nuclear DNA analysis). Such detailed study of selected sites would surely determine whether the two taxa are reproductively isolated. *Phyciodes* are easy to rear and females lay clusters of eggs of several dozen to a hundred eggs when placed in a jar with aster leaves and (in dry places such as Colorado) a bit of moisture and kept in mild shade (in a pickup camper with open windows or near the window of a house for instance, always protected from direct sun which cooks the butterflies), so numerous specimens can readily be reared, making such research quite feasible, but the research will still require time and effort. Studies of DNA phylogeny should be done where several taxa are thought to both occur (although mtDNA in *Phyciodes* is rather variable and does not work very well, Wahlberg et al. 2003, so nuclear DNA will be vastly superior).

**Table 1**. Forewing length (mm) averages of *Phyciodes* butterflies in Vermont. Three species of butterflies evidently occur, but only two groups could be reliably identified in most of Vermont. Two of the three species, *P. tharos* and *P. diminutor*, have two generations, while *P. cocyta selenis* has just one generation but is evidently included in the first generation of the "*P. cocyta*-group" in the table because specimens could not be operationally distinguished from *P. diminutor diminutor* which apparently flies in both the first and second generations of this identification group. The break between first generation and second generation was determined by inspection of the graphed collection/photograph records, and this break is a little different for the three identified groups, as noted.

| three groups of taxa | First Generation | Second Generation |
|---|---|---|
| *P. tharos* (*includes those identified with less certainty as *P. tharos*?) | 1st generation April 24 to July 14<br>males 16.0 (16.0*), n=11 (17*)<br>females 17.5 (17.7*), n=18 (36*) | 2nd generation July 16 to Sept. 21<br>males 15.8 (15.8*), n=26 (33*)<br>females 16.4 (17.0*) n=12 (30*) |
| "*P. cocyta*-group" (includes *P. cocyta selenis* in the first generation & *P. diminutor diminutor* in both generations) from northern Vermont south through most of Vermont to Rutland & Windsor Counties | 1st generation May 27 to July 21<br>males 17.2, n=193<br>females 18.9, n=27 | 2nd generation July 25 to Sept. 18<br>males 16.5, n=25<br>females 18.0, n=7 |
| *P. diminutor diminutor* (mostly) from Bennington & Windham Counties in southern Vermont | 1st generation May 5 to June 24<br>males 16.2, n=13<br>females 18.0, n=2 | 2nd generation July 12 to Oct. 5<br>males 16.3, n=38<br>females 18.3, n=8 |

**Table 2**. Forewing length versus altitude (in feet) for Vermont *Phyciodes*. Averages and approximate medians (the midpoint length if n=odd, or the just-shorter length if n=even) are both listed. Only the definitely-determined males and females were included for "*P. cocyta*", but for *P. tharos* both the definite "*P. tharos*" and the more questionable "*P. tharos*?" were included. Some specimens lacked altitude information at this time so could not included. Some specimens had their recorded altitudes without units (meters or feet) so could not be included. Photographed specimens vary in scale and could not be measured for forewing length so could not be included. Single specimens (n=1) are single measurements, not averages. Females average about 2 mm larger than males.

| Forewing length (mm) | *Phyciodes tharos* males (mean 822 ft., n=47) | *Phyciodes tharos* females (mean 891 ft., n=58) | *Phyc.* "*cocyta*" males (mean 1,070 ft., n=220) | *Phyc.* "*cocyta*" females (mean 1,020 ft., n=38) |
|---|---|---|---|---|
| 14 mm | 1,151 ft., n=3 median 656 ft. | --- | --- | --- |
| 14.5 mm | 1,729 ft., n=1 | --- | 784 ft., n=1 | --- |
| 15 mm | 782 ft., n=6 median 495 ft. | 892 ft., n=4 median 697 ft. | 1,018 ft., n=13 median 1,026 ft. | --- |
| 15.5 mm | 1,018 ft., n=3 median 1,018 ft. | 315 ft., n=1 | 1,047 ft., n=7 median 1,079 ft. | 1,700 ft., n=1 |
| 16 mm | 743 ft., n=25 median 689 ft. | 802 ft., n=5 median 696 ft. | 1,098 ft., n=40 median 1,099 ft. | --- |
| 16.5 mm | 1,017 ft., n=2 median ~1,017 ft. | 612 ft., n=4 median 489 ft. | 870 ft., n=17 median 883 ft. | 160 ft., n=1 |
| 17 mm | 517 ft., n=6 median 727 ft. | 1,081 ft., n=15 median 813 ft. | 1,105 ft., n=74 median 1,083 ft. | 513 ft., n=5 median 542 ft. |
| 17.5 mm | --- | --- | 1,273 ft., n=17 median 1,200 ft. | --- |
| 18 mm | 1,992 ft., n=1 | 763 ft., n=15 median746 ft. | 1,083 ft., n=42 median 997 ft. | 2,050 ft., n=4 median1,402 ft. |
| 18.5 mm | --- | 926 ft., n=4 median 577 ft. | 820 ft., n=2 median, 718 ft. | 882 ft., n=4 median 955 ft. |
| 19 mm | --- | 1,016 ft., n=10 median 797 ft. | 732 ft., n=5 median, 608 ft. | 968 ft., n=15 median 738 ft. |
| 19.5 mm | --- | --- | 420 ft., n=1 | 917 ft., n=3 median 992 ft. |
| 20 mm | --- | --- | 700 ft., n=1 | 1,070 ft., n=5 median 1,011 ft. |

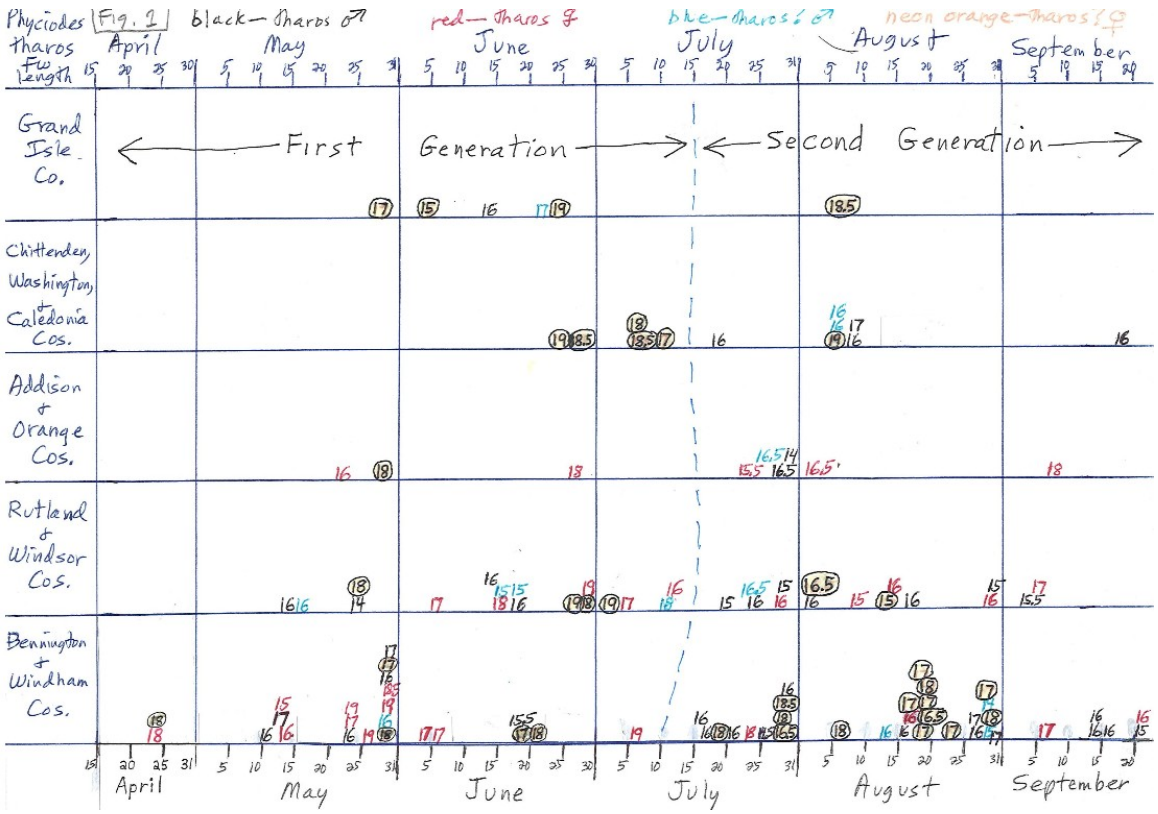


**Fig. 1**. Flight periods of *Phyciodes tharos tharos* in Vermont. The five rows of specimens are plotted from north (top) to south (bottom). Black numbers are fw length of confidently-identified males. Red numbers are fw length of confidently-identified females. Blue numbers are fw length of less-confidently-identified males. Black numbers inside black circles are fw length of less-confidently-identified females.

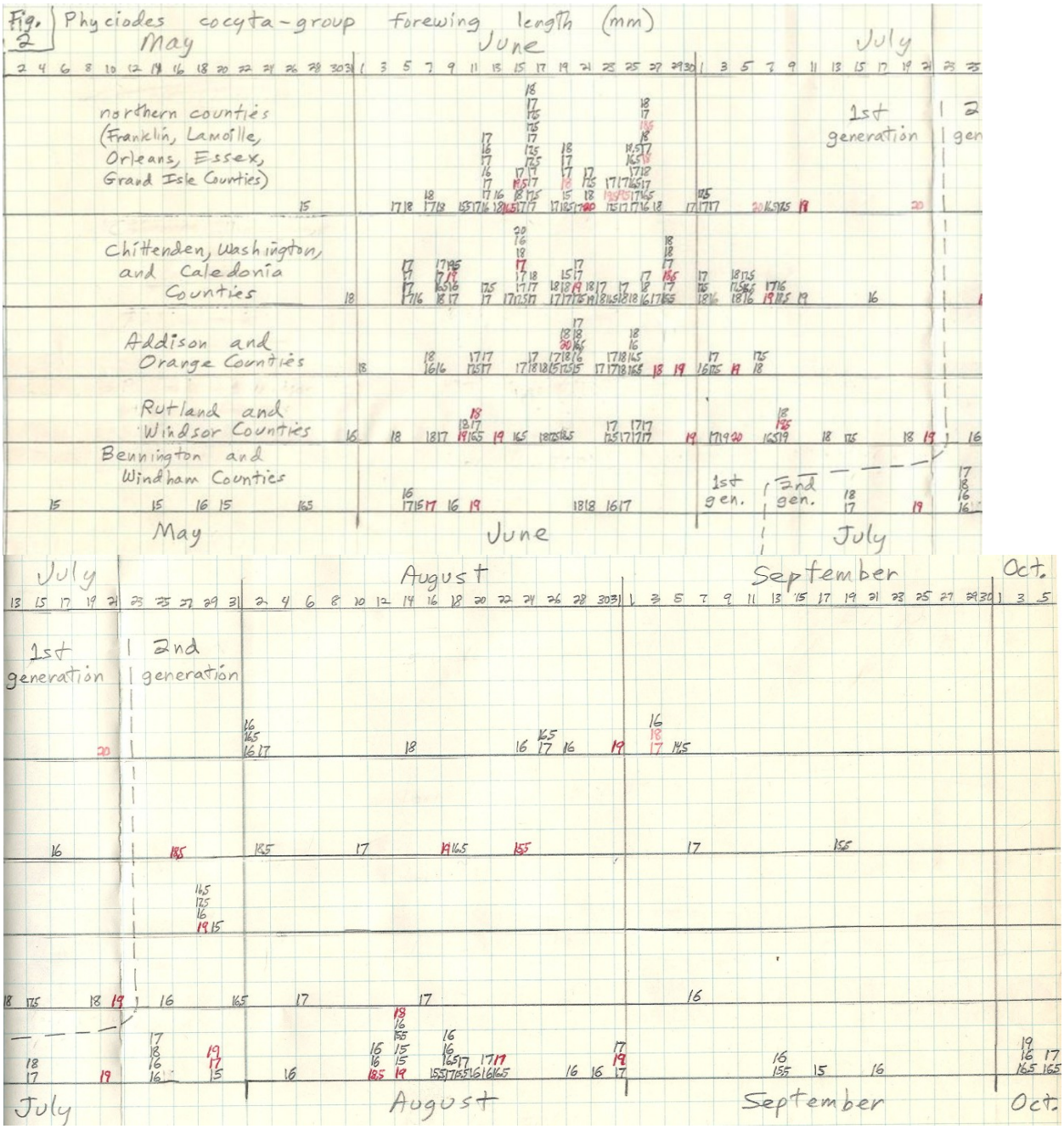


**Fig. 2**. Forewing length (mm) of combined specimens of *Phyciodes diminutor diminutor* and *P. cocyta selenis* from Vermont. Black numbers are fw length of males. Red numbers are fw length of females. The dashed line separates the presumed usual gap between first generation and second generation adults.

Figure 3. *Phyciodes tharos tharos* from Vermont. Starting at top of left column going down, Bennington Co. 9m3f, Windham Co. 1m1f, Rutland Co. 5m3f, Addison Co. 1m2f.

Figure 4. Combined specimens of *Phyciodes cocyta selenis* and *P. diminutor diminutor* in Vermont. Starting at top of left column going down, Bennington Co. 11m7f (these are surely mostly *P. diminutor*), Windham Co. 2m1f (also mostly *P. diminutor*), Rutland Co. 1f, Windsor Co. 2m1f, Washington Co. 2m1f, Lamoille Co. 5m, Franklin Co. 1m1f, Orleans Co. 1m, Essex Co. 2m1f.

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# B. *PHYCIODES* FROM LUCAS COUNTY OHIO

*Phyciodes tharos tharos* and *P. diminutor diminutor* occur in Ohio (Scott 2006), where identification is more difficult than usual. *P. tharos* occurs all over the state, while *P. diminutor diminutor* occurs only in northern Ohio (Wood, Lucas, Sandusky, and Columbiana Cos. are reliably recorded so far).

This paper reports the identification of *Phyciodes* from Lucas Co. Ohio, based on 49 specimens collected by Tom Carr that were loaned/gifted to Scott. The results are presented below. I can "identify" most of them, though it was noted on the ID labels that ~13 are somewhat questionable. Figs. 1-3 illustrate those now in the Scott collection. Additionally, a recent mtDNA study of *Phyciodes* (Proshek & Houghton 2012) sequenced five specimens from Lucas Co. reported as *P. tharos*, but I have examined them (see part C below) and found that one of them is actually *P. diminutor*.

Examination of the 49 specimens suggests that considerable introgression has occurred in this area. The size is somewhat variable and the real *tharos* seem to be only 1 mm or so smaller in fw length than the real *diminutor*. The antenna nudum color is variable too (Iftner et al. [1992] wrote that the antenna club color is unreliable in Ohio), though evidently the majority of the real *tharos* have black nudum but some have orange nudum, and evidently nearly all of the real *diminutor* have orange nudum. The antenna club shape is variable, but the real *tharos* evidently mostly have an oval club, while real *diminutor* have elliptical or oval-elliptical and sometimes even an oval club. The uph center of real *tharos* usually has a black line across it but some have a small or even large space due to the line being missing, while real *diminutor* usually has the uph space but some have a thin line across it. The unh marginal patch (around or over the crescent) is mostly narrower and darker in real *tharos*, and wider and paler (more orange-brown) in real *diminutor*, but a lot of these bugs were caught around May 20 and are form marcia which has enlarged brown unh patches so the size of the patch can't be compared in those very well to the July and Sept. adults. The real *P. tharos* seems to have two or three generations in May and July and Sept. (note that Iftner et al. 1992 show a histogram proving that the first generation is L April-E June, and the 2nd and 3rd generations form a large peak L June-E Oct. that evidently represents the merged 2nd and 3rd generations, or represents records of three generations in S Ohio lumped with two generations in N Ohio), while the real *P. diminutor* are mostly from May but there is a definite male from Sept. 16, and there are some July ones but those are questionable and could be *tharos* (*P. diminutor* in S Minnesota and Ont. and N N.Y. and Vermont has two generations). Females are much harder to identify as the species aren't as different in females. Some of these bugs seem to have about every possible combination of traits, which might give fodder to the folks who believe that they are all just one species, but I think there are mostly the two species, and we have to consider what happens elsewhere also in interpreting Ohio bugs. The bugs studied by Porter & Mueller (1998) from Providence in Lucas Co. July 30, and from Cygnet in Wood Co. Sept. 5 were misidentified by them and I borrowed and re-identified <u>all</u> of those specimens later (Scott 2006) as *P. diminutor* (those specimens were 16-17 mm, rarely 15 & 18; uph usually had a large space; antenna nudum usually was orange rarely blackish; antenna club was elliptical or even elongate; unh marginal patch was mostly like *diminutor*). But Tom Carr collected many *P. tharos* also in Lucas Co. Ohio. In Columbiana Co. in NE Ohio, studied by Porter & Mueller (1998), most of the *P. diminutor* specimens I identified had blackish nudum, so there must be a lot of introgression going on in Ohio. Charles Oliver wrote about Pennsylvania populations with odd traits including just two generations, so I think

that *P. tharos* must occur all over Penn. and *P. diminutor* must occur over much of it too (the two-generation populations in particular are evidently *diminutor*), and *P. diminutor incognitus* Gatrelle has two generations and evidently extends into E Penn. in the Pocono Mts. where they are large in size so could be considered to be *incognitus*. (Obviously more research should be done on eastern *Phyciodes*, which Harry Pavulaan and David M. Wright and others are slowly pursuing). And the one-generation populations extending as far south as West Virginia and Virginia can be considered to be *P. cocyta selenis* for now.

Of course the study of mtDNA is just a fad. It replaced the electrophoresis fad, which is now dead. The mtDNA fad will not be missed when it dies as the expense for sequencing nuclear genes declines, because the future is the study of nuclear genes. mtDNA has the huge flaw of being maternally inherited, so just a little hybridization between two taxa can introduce the mtDNA into the other species, and it can spread through and replace the original mtDNA completely, even while almost none of the nuclear genes are changed. That makes it bad to use for the study of phylogeny.

A good lesson here is that, unless hybridization is being studied, only confidently-identified specimens should be used for DNA sequencing. For example McHugh et al. (2013) published a study of mtDNA of *Argynnis* (*Speyeria*), while some of the specimens were misidentified (the McHugh thesis illustrated *Speyeria* "*callippe elaine*" for instance which is definitely not that and appears to be *S. zerene*). Only about 20% of the specimens used in that paper were illustrated in the thesis and many were very battered, so there is evidently no way to check the identifications of most of those specimens, so that paper might be considerably flawed due to misidentifications.

How should we study and identify *Phyciodes* in northeastern U.S.? The best way is to go out in nature and search for eggs or young larvae on the asters, and rear them to adults. Finding young larvae is far easier than eggs, because young larvae make a dark mess on the leaf which shows clearly through to the upperside, making the leaf quite visible so one can quickly scan many aster plants for ruined discolored twisted leaves. 3$^{rd}$-stage larvae are just as easy to find but they are experiencing the photoperiod in nature that causes them to go into diapause as unfed 4$^{th}$-stage larvae, making them very difficult to rear in the lab, so one should look for 1$^{st}$-2$^{nd}$-stage larvae. Finding postdiapause older 4$^{th}$-5$^{th}$ stage larvae is nearly impossible because they rest in litter during daytime so one must look for a highly-chewed plant then paw through the litter below to try to find the dark camouflaged larvae hiding there, a very difficult time-consuming process. Anyway, when you get or find those clusters, you can rear them in 3-4 weeks by giving them fresh aster leaves from fridge every 2 days, and I take photos of larvae and pupae, and then if 10 or more adults hatch out you have many to consider and you can make a good identification; I have never failed to "identify" a family like that with confidence. That way you identify the natural hosts too (some *Phyciodes* are quite specific in their asters chosen, which definitely helps make identification and taxonomic decisions), plus you can record whether the very young larvae make a strong or weak or no silk web over the leaf, etc. *Aster simplex* is a major host in Minn. and evidently in Penn. too, so I would expect that it would be a big host for these Lucas Co. Ohio bugs, as it is probably common there, along with some other asters.

**Fig. 5**. *Phyciodes* from Lucas Co. Ohio, upperside (top photo), underside (bottom photo). Specimens are numbered starting left column top to bottom then next column top to bottom etc. Probable IDs of #1-6 are *P. tharos tharos* 6m, #7-13 are *P. diminutor diminutor* 6m1f (#13 is the only female). Summer form #1-3, 6; form *marcia* #4-5, 7-13. Site data and details of the antenna and wing traits of each specimen are given below in list of Specimens Identified.

Specimens Identified

49 *Phyciodes* from Lucas Co. Ohio, coll. Tom Carr, 2008, are listed below. About 13 are quite questionable in identification, but the majority seem to represent the two species *P. tharos tharos* (23 probable or most likely) and *P. diminutor diminutor* (26 probable or most likely). Three labels were placed on each specimen: a label "*Phyciodes* [species] determined by James Scott, January 2009", a label describing the traits of the specimen, and a locality/date label.

Most specimens are from Ohio, Lucas Co., Toledo Area Metroparks (or Metroparks property), Bend View area, 10,705 U.S. 24, old field habitat, so this site is abbreviated as "Toledo/Bend View" below.

*P. tharos tharos* male, 17 mm, nudum black, club oval, unh patch narrow not dark , uph line present but thin; Toledo/Bend View, Sept 1, 2008 (now in J. Scott collection, **fig. 5 #1**).

*P. tharos tharos* male, 15.5 mm, nudum black, club oval, unh patch narrow & dark, uph line strong; Toledo/Bend View, Aug. 26, 2008.

*P. tharos tharos* male, 17 mm, nudum black, club oval, unh patch narrow & dark, uph line strong; Toledo/Bend View, July 13, 2008.

*P. tharos tharos* male, 14 mm, nudum black, club oval, unh patch narrow & dark, uph line strong; Toledo/Bend View, Sept. 16, 2008.

*P. tharos tharos* male, 16 mm, nudum black, club oval, unh patch narrow but not dark, uph line present; Toledo/Bend View, July 15, 2008 (now in J. Scott collection, **fig. 5 #2**).

*P. tharos tharos* male worn, 16 mm, nudum black, club oval, unh patch fairly narrow & dark (not form marcia!), uph line present; Toledo/Bend View, May. 19, 2008.

*P. tharos tharos* male, 16 mm, nudum black, club oval, unh patch not narrow but dark, uph line strong; Toledo/Bend View, July 15, 2008 (now in J. Scott collection, **fig. 5 #3**).

*P. tharos tharos* male, 17 mm, nudum black, club rather elliptical, unh patch fairly wide not dark, uph has line; Toledo/Bend View, May 17, 2008.

*P. tharos tharos* male, 17 mm, nudum black, club oval, unh patch large & dark but form marcia, uph has a space due to weak line; Toledo/Bend View, May 23, 2008 (now in J. Scott collection, **fig. 5 #4**).

*P. tharos tharos* evidently male, 17 mm, nudum black, club oval, unh patch not very dark & wide but form marcia, uph has a space due to very weak line (ups rather orangish); Toledo/Bend View, May 20, 2008.

*P. tharos tharos* male, 16 mm, nudum black, club oval, unh patch fairly wide (& not dark) but form marcia, uph has a 2-cell space due to weak line; Toledo/Bend View, May 29, 2008 (now in J. Scott collection, **fig. 5 #5**).

*P. tharos tharos* male slightly worn, 16 mm, nudum black, club mostly oval, unh patch fairly wide (for a male) & dark but somewhat form marcia, uph has 3-cell space due to weak/absent line; Toledo/Bend View, May 20, 2008.

*P. tharos tharos* evidently (?) male, 17 mm, nudum black, club oval, unh patch narrow but not dark, uph has giant space (so does upf); Toledo/Bend View, Sept. 16, 2008.

*P. tharos tharos*? male worn, 16 mm, nudum orange, club broken, unh patch fairly wide but form marcia & not dark, uph has line; Toledo/Bend View, May 25, 2008.

*P. tharos tharos* male, 16.5 mm, nudum orange, club elliptical, unh patch dark & narrow, uph has line; Toledo/Bend View, July 15, 2008.

*P. tharos tharos*? male, 17 mm, nudum orange, club mostly oval, unh patch rather dark & narrow, uph has thin black line; Toledo/Bend View, July 15, 2008 (now in J. Scott collection, **fig. 5 #6**).

*P. tharos tharos*? male, 16 mm, nudum orange, club oval-elliptical, unh patch fairly dark & narrow, uph has strong line; Toledo/Bend View, July 13, 2008.

*P. tharos tharos* female, 18 mm, nudum black, club oval, unh patch fairly small for a female and dark, uph has strong line; Toledo/Bend View, July. 18, 2008.

*P. tharos tharos* female, 17 mm, nudum black, club oval, unh patch narrow for a female not very dark, uph has strong line; Toledo/Bend View, Sept. 16, 2008.

*P. tharos tharos* female, 17 mm, nudum black, club oval-elliptical, unh patch fairly small & dark, uph has line; Toledo/Bend View, July 13, 2008.

*P. tharos tharos* female, 19 mm, nudum black, club oval, unh patch fairly dark & fairly wide but form marcia, uph has strong line; Toledo/Bend View, May 25, 2008.

*P. tharos tharos* female, 17 mm, nudum black, club oval, unh patch fairly small (for a female) & dark, uph has good line; Toledo/Bend View, July 15, 2008.

*P. tharos tharos*? or *P. diminutor diminutor*? female, 17 mm, nudum orange, club oval-elliptical, unh patch fairly small, uph has line; Ohio, Lucas Co., Oak Openings Metropark, old field west side of Girdham Road, ca. 2 mi. S of Sager Road, Aug. 27, 2008.

*P. diminutor diminutor* male, 17 mm, nudum brownish-orange, club elliptical, unh patch fairly dark & wide but form marcia & not dark, uph has large space; Toledo/Bend View, May 19, 2008.

*P. diminutor diminutor* male, 17 mm, nudum orange-brown, club oval-elliptical, unh patch wide & fairly dark but form marcia, uph has large space; Toledo/Bend View, May 19, 2008.

*P. diminutor diminutor* male, 17 mm, nudum orange, club elliptical, unh patch not dark & fairly wide but form marcia, uph has large space (upf orangish too); Ohio, Lucas Co., Oak Openings Metropark, N side of Monclova Road, ½ mile E of Girdham Rd., disturbed prairie habitat, May 17, 2008.

*P. diminutor diminutor* male, 16.5 mm, nudum orange, club elliptical, unh patch pale & wide but form marcia, uph has line; Toledo/Bend View, May 20, 2008.

*P. diminutor diminutor* male, 16.5 mm, nudum orange, club oval-elongate, unh patch fairly wide & pale, uph has large space; Toledo/Bend View, Sept. 16, 2008.

*P. diminutor diminutor* male, 17 mm, nudum orange, club elliptical, unh patch wide but form marcia, uph has space due to very weak line; Toledo/Bend View, May 19, 2008 (now in J. Scott collection, **fig. 5 #7**).

*P. diminutor diminutor* male, 16 mm, nudum orange, club elliptical, unh patch rather dark & fairly wide but form marcia, uph has giant space; Toledo/Bend View, May 17, 2008.

*P. diminutor diminutor* male, 18 mm, nudum orange, club mostly elliptical, unh patch wide fairly dark & wide but form marcia, uph has giant space; Ohio, Lucas Co., Oak Openings Metropark, Old Reed Road between Girdham & Wilkins Roads, May 17, 2008 (now in J. Scott collection, **fig. 5 #8**).

*P. diminutor diminutor* male, 17 mm, nudum orange, club oval-elliptical, unh patch dark & wide but form marcia, uph has giant space; Toledo/Bend View, May 25, 2008.

*P. diminutor diminutor* male, 17 mm, nudum orange, club oval-elliptical, unh patch fairly dark & fairly wide but form marcia, uph line very weak; Toledo/Bend View, May 19, 2008 (now in J. Scott collection, **fig. 5 #9**).

*P. diminutor diminutor* male, 18 mm, nudum orange, club oval-elliptical, unh patch a little dark & fairly wide but form marcia, uph has space; Toledo/Bend View, May 19, 2008.

*P. diminutor diminutor* male, 18 mm, nudum orange, club oval-elliptical, unh patch a little dark & fairly wide but form marcia, uph has space; Toledo/Bend View, May 23, 2008 (now in J. Scott collection, **fig. 5 #10**).

*P. diminutor diminutor* male, 17 mm, nudum orange, club oval-elliptical, unh patch fairly light & wide but form marcia, uph line weak; Toledo/Bend View, May 19, 2008.

*P. diminutor diminutor* male, 17 mm, nudum orange, club oval-elliptical, unh patch fairly dark & wide but form marcia, uph has space in 1+ cells; Toledo/Bend View, May 20, 2008 (now in J. Scott collection, **fig. 5 #11**).

*P. diminutor diminutor* male, 15 mm, nudum orange, club oval-elliptical, unh patch somewhat dark & wide but form marcia, uph has weak line; Toledo/Bend View, May 29, 2008.

P. evidently *diminutor diminutor*? male, 16 mm, nudum orange, club oval, unh patch fairly dark & wide but form marcia, uph has big space; Toledo/Bend View, May 20, 2008 (now in J. Scott collection, **fig. 5 #12**).

P. probably *diminutor diminutor*? (maybe *tharos*) male, 17.5 mm, nudum orange, club oval, unh patch fairly dark & not wide, uph has big space; Toledo/Bend View, July 13, 2008.

*P. diminutor diminutor*? male, 17 mm, nudum black, club broken, unh patch pale & fairly wide, uph has space in 1+ cells; Toledo/Bend View, July 22, 2008.
*P. diminutor diminutor*? (*tharos*?) male, 16 mm, nudum orange, club oval-elliptical, unh patch dark & narrow, uph has very weak line; Toledo/Bend View, July 22, 2008.
*P. diminutor diminutor*? (or *tharos*?) male, 17 mm, nudum orange, club rather oval, unh patch dark & narrow, uph has giant space; Toledo/Bend View, July 15, 2008.
*P. diminutor diminutor* female, 18.5 mm, nudum orange-brown, club elliptical, unh patch large but form marcia, uph has 2-cell space; Toledo/Bend View, May 20, 2008 (now in J. Scott collection, **fig. 5 #13**).
*P. diminutor diminutor* female, 20 mm, nudum orange, club elliptical, unh patch dark & wide but form marcia, uph has weak line; Toledo/Bend View, June 2, 2008.
*P.* probably *diminutor diminutor* female, 17 mm, nudum dark-orange, club elliptical, unh patch not dark & wide but form marcia, uph has line; Toledo/Bend View, May 23, 2008.
*P. diminutor diminutor*? female, 19.5 mm, nudum orange-black, club elliptical, unh patch large but form marcia, uph has line; Toledo/Bend View, May 23, 2008.
*P. diminutor diminutor*? female, 17.5 mm, nudum mostly black but has orange tip, club fairly elliptical, unh patch large & fairly dark, uph has strong line; Toledo/Bend View, July 13, 2008.
*P. diminutor diminutor* ? (*tharos*?) female, 19 mm, nudum mostly orange, club oval-elliptical, unh patch not dark & large but form marcia, uph has thick line; Toledo/Bend View, May 19, 2008.

## ***Phyciodes*** **in the rest of Ohio**.

In Papilio (New Series) #13 pp. 16-17 I reidentified the specimens used by Porter & Mueller (1998) for their electrophoresis study, and found that the Ohio specimens they used were *P. diminutor diminutor*, from Lucas and Wood Counties in NW Ohio, and from Columbiana Co. in NE Ohio. Introgression was evident in the Columbiana Co. specimens, which had antenna nudum blacker than normal, evidently because of introgression with *P. tharos*. I did not find *P. tharos* in those specimens, though it must occur all over Ohio, and the specimens collected at any locality and date depend on variables such as timing of the generations and the population cycles and habitat factors etc., with a healthy amount of randomness thrown in. In decades of studying both *P. tharos* and *P. diminutor diminutor* in extreme S Minnesota (Freeborn Co.), I found their populations cycle independently to a considerable extent, and sometimes *diminutor* would be hugely abundant locally when *tharos* was scarce.

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# C. *PHYCIODES* FROM MICHIGAN AND LUCAS CO. OHIO USED FOR A DNA STUDY

Proshek & Houghton (2012) published a mtDNA study of the *Phyciodes tharos*-group in Michigan and Ohio in part because of my finding (Scott 2006) that many of the specimens in the study of Michigan *Phyciodes* by Porter & Mueller (1998) were misidentified. Unfortunately someone mistakenly did a ReplaceAll command in a word processor on the entire manuscript (except the figures), replacing all the *batesii* words by *cocyta*, making much of the paper read as nonsense, so Proshek (2012) published a correction. They also found that mtDNA is highly polymorphic in these bugs, so is rather useless for determining their phylogeny. My own paper (Wahlberg et al. 2003) demonstrated that polymorphism, and that paper's main useful finding was that *tharos* was not as variable and is a little separable from *cocyta*. Proshek & Houghton used five specimens from Lucas Co. Ohio, which they reported as *P. tharos*, but I found that one or two of them are actually *P. diminutor*. But the other four validly-identified *tharos* clustered with many *cocyta*, so mtDNA cannot separate those well either. The identity of these specimens does not change the conclusion that I draw from multiple studies, that variation is extreme and overlaps greatly in all the species.

David Houghton and Benjamin Proshek kindly loaned all 141 specimens in their study to Scott, and this paper reports on those specimens, specifically their identification and variation. The 141 *Phyciodes* were collected in Michigan and Ohio by Benjamin Proshek in 2006 (not 2007), including 42 *P. batesii lakota*, 83 *P.cocyta selenis*, 8 *P. tharos tharos*, and 8 *P. diminutor diminutor*. 40 of those specimens were used in a study of their mtDNA by Proshek & Houghton (2012, the 40 listed on p. 49). My identification labels were placed on each specimen, and red-ink labels "DNA STUDY B. Proshek & D. Houghton J. Lepid. Soc. 66:49" were placed on each specimen that was used for DNA in that study. All 141 specimens were numbered from 1 to 141 on their locality labels by Proshek. 127 of them including all the mtDNA specimens are now deposited in the McGuire Center, Gainesville, Florida, and 14 wing-chipped duplicates are now in the collection of >5,000 *Phyciodes* of James Scott.

In brief, most identifications by Proshek were correct, except for seven females Proshek identified as *P.* "*batesii*" which I identify as *P. cocyta* (#054*, 069*, 071, 113, 114, 116, 123, all from Crapo Lake Road, Otsego Co. Mich.), a pair from Ohio identified as *P.* "*tharos*" that I identify as *P. diminutor* (136* male and 138 female), and six females from S Mich. identified as *P.* "*cocyta*" that I identify as *P. diminutor* (126, 127, 128*, 129, 130, 131). Four of those misidentifications were used in the mtDNA study (those with *). Of those four, the two mtDNA-studied *cocyta* cluster with other *cocyta* on their phenogram, while the two *diminutor* cluster with *P. tharos*. The mtDNA paper unfortunately did not consider *diminutor* as a separate taxon.

Following is a list of all specimens with discussion of phenotype and variation. Numbers such as 073*m mean specimen #073* male, 062f means specimen #062 female, etc., and * denotes specimens used for mtDNA. (P. 49 of Proshek & Houghton 2012 lists 2007 for the year of capture of all 40 mtDNA specimens, but the labels on all 141 specimens say 2006.)

***Phyciodes batesii lakota***. Males are easily separable from sympatric *P. cocyta* by having a blackish-brown antenna club nudum, blacker upf, a large unf median posterior black spot, and smaller unh patch. The upf postmedian band usually a little paler in both sexes. But some females are very similar to *P. cocyta* as the variation of the traits barely overlaps. The antenna club nudum of males is mostly blackish-brown with two adjacent ladderlike sets of brown to

(less-often) tawny-orange steps, and in females is mostly blackish-brown (seldom brown) with dark-brown to brown steps, but about 40% of females have the steps orangish, thus some females are similar to *P. cocyta*. The unf median posterior black spot is large in males, usually long in females but often squat and separated into two black dots in many. The unh submarginal patch is usually only moderate in size in males, covering the black dots at most, but smaller on many, and very small in about a third (just a trace on three males); in females it is moderate (covering some black dots) in most, smaller in 20%. The unh crescent is pale-yellow in most males and dull-cream in nearly a third, pearly-white in several and rarely brown; in females the crescent is almost always pearly-white, rarely brownish-cream. The unf black tornus spot is large in males, very large in several; it is smaller in females, rarely large. 42 specimens were identified from central Michigan June 2006 B. Proshek.

***Phyciodes cocyta selenis***. Males are easily distinguishable from *P. batesii* by having an orange antenna club nudum, small unf median posterior black spot, larger unh brownish patch, oranger upf, and mostly an oranger uph with less of the line across the orange central area. But females are harder to separate and some are very similar. The antenna club nudum on females is orange in most females but varies to brown in some females and thus resembles some *batesii* (and some *batesii* females have somewhat orangish nudum). The female ups is rather similar to *P. batesii* but the upf is a little oranger in a slight majority of females (the upf varies and can be quite melanic). The unf median posterior black spot is nearly always smaller, while the unh brownish patch is very large (almost always larger). The unh patch usually lacks a crescent in males but is present and whitish in most females. Thus seven females from Crapo Lake Road (054*f, 069*f, 071f, 113f, 114f, 116f, 123f) were identified as *P. batesii* by B. Proshek, but I identify them as evidently *P. cocyta* based on the majority of these traits. Females 054* and 069* cluster closer to other *P. cocyta* on the phenogram, which adds a bit more certainty to their identification as *P. cocyta* rather than *P. batesii*. Wahlberg et al. (2003) thought that there was considerable ancient introgression between *cocyta* and *batesii*, which currently occurs only in western U.S. Specimens:

Frank Smith Road, 0.7 mi. S of Old M63, Lake Co. Michigan June 6 2006 B. Proshek (003*m 004f 005*m 006*m 007f 008f 009*m 010*m 011m 012m 013*m 014*m).

Junction of Old M63 and King's Highway, Lake Co. Michigan June 9 2006 B. Proshek 039*m.

0.5 mi. SW of 2 ½ Mile Road & Old M63 road, Lake Co. Michigan June 10 2006 B. Proshek (042m 043*m 044m 045*m 046*m 047*m 048m 049*f 050*m 051m 052f).

Gordon Biological Station, Luther, Lake Co. Michigan June 6-7-10 2006 B. Proshek (001f 002m 015m 016m [now in J. Scott coll.] 017*m 018*m 019f 040m 041f).

Silver Creek Campground, Pierre-Marguette State Forest, Lake Co. Michigan June 8 2006 B. Proshek (020m 021m).

Silver Creek Pathway, Pierre-Marguette State Forest, Lake Co. Michigan June 8 2006 B. Proshek (022f 023m 024m 025*f 026f [now in J. Scott coll.] 027m 028f 029*m 030f).

Lincoln Bridge Landing, Pierre-Marguette State Forest, Lake Co. Michigan June 8 2006 B. Proshek (031m 032m 033*m [J. Lepid. Soc. 66:49 wrongly lists this specimen from Silver Creek Pathway] 034m 035m 036m).

Lincoln Bridge Pathway, Pierre-Marguette State Forest, Lake Co. Michigan June 8 2006 B. Proshek (037*m [J. Lepid. Soc. 66:49 wrongly lists this specimen from Silver Creek Pathway] 038m).

Crapo Lake Road, 0.2-0.7 mi. S of Old State Road, Otsego Co. Michigan 2006 B. Proshek (0.2 mi. S June 13 for #071f [now in J. Scott coll.]; 0.3 mi. S June 13 055*m 065*m; 0.4 mi. S June 13 053*m 054*f 069*f; 0.5 mi. S June 19 113f 114f; 0.6 mi. S June 19 116f 117m 118m [now in J. Scott coll.]; 0.7 mi. S June 19 123f).

S7 Road, 0.5 mi. N of M55 road, Wexford Co. Michigan June 15 2006 B. Proshek (086m 087m).

6739 State Road, 0.5 mi. S of W50 road, Wexford Co. Michigan June 15 2006 B. Proshek (088m 089m 090f 091m).

Long Lake Campground, NE of Cadillac, Wexford Co. Michigan June 16 2006 B. Proshek (093f 094m 095m 097m 098m 099*m 100f 101f [now in J. Scott coll.] 102m 105m [now in J. Scott coll.]).

Sunset Trail Road, 1 mi. N of M77, Kalkaska Co. Michigan June 17 2006 B. Proshek (103f 104m).

31 road, 1.5 mi. S of Baxter Bridge, Wexford Co. Michigan June 16 2006 B. Proshek (092f—this female may be *P. batesii*).

***Phyciodes diminutor diminutor***. This species is very similar to *P. cocyta*, but is mostly a little smaller and has two generations, versus one in the slightly-larger *P. cocyta*. The two are sympatric in Ontario and New York (research by Alan Wormington and Paul Catling, see Scott 2006) so I currently treat them as separate species rather than a ssp. of *P. cocyta*. *P. diminutor* evidently ranges from S Minn. & NE Iowa E to N Ohio Ont. N.Y. S Vermont Penn., while *P. diminutor incognitus* occurs southward to South Carolina, Georgia, and Kentucky and is larger but still has two generations (Scott 2006). More research is needed on it. Paul Catling (1997a,b) found the two sympatric in Ontario and New York, and noted oviposition on *Aster lateriflorus* in N New York, and it feeds on *Aster simplex* in S Minn. It's interesting that mtDNA of two of these *diminutor* from Ohio (136*m, 138f) clustered with *P. tharos*, as did some *P. diminutor incognitus* from N.C. (N. Wahlberg, pers. comm.), while two *P. diminutor diminutor* from S Minn. clustered with *P. cocyta* (Wahlberg et al. 2003), showing that mtDNA is useless for classifying it as well due to introgression etc. Specimens:

Wabash Cannonball Bike Trail (S Branch) at Black Road, Lucas Co. Ohio June 30 2006 B. Proshek (136*m, 138f). The male #136* (**Fig. 6 #9**) is obviously *diminutor* and is not like the 8 sympatric *tharos* noted below because its nudum is orange, the upf and uph have a large orange area without a line, and the unh brown patch is much larger. The female #138 (**Fig. 6 #10**) is probably *P. diminutor*, possibly *P. tharos*, because it is larger and the unh brown patch is larger, and its brownish-orange nudum occurs on some female *cocyta/diminutor*.

The following specimens from southern Michigan are surely *P. diminutor* rather than *P. cocyta*, because I found that all the specimens from S Mich. studied by Porter & Mueller (1998) were *diminutor*, so they are in the range of known *diminutor*, and they are all females suggesting that they were collected at the end of a first generation and the second generation would presumably occur there in Aug.-Sept. The antenna club nudum varies from orange to brown in these, variation known to occur in both *cocyta/diminutor*.

Hawley Road, 1 mi. S of Ellison Road, Ionia Co. Michigan, June 20 2006 B. Proshek (126f, 127f, 128*f (**fig. 6 #11**), 129f, 130f).

91 [road] 3 mi. N of 57 [road], Montcalm Co. Michigan June 20 2006 B. Proshek 131f (**fig. 6 #12**).

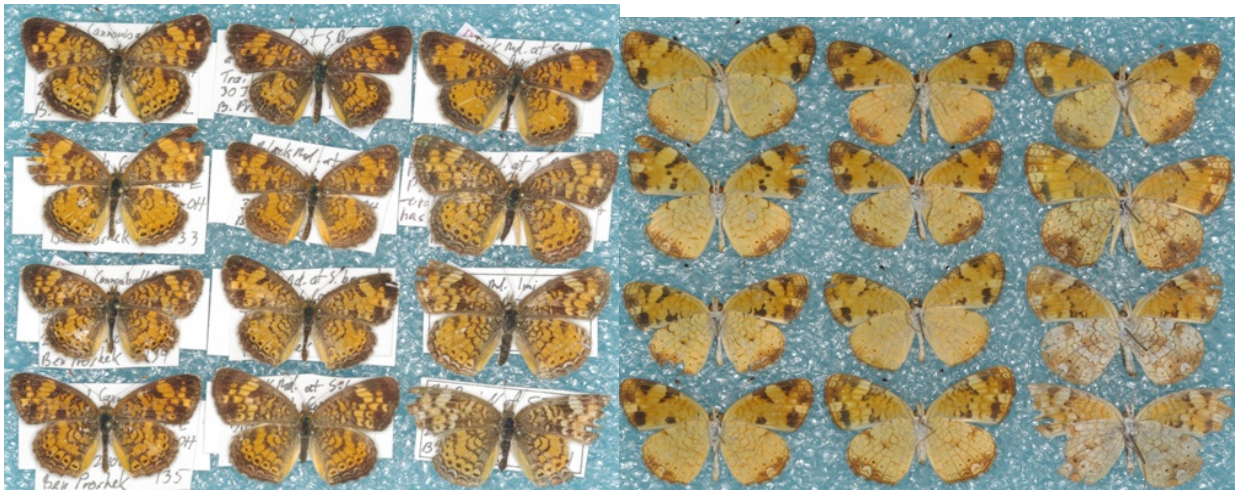

Fig. 6. *P. tharos tharos* (left two columns, #1-8 by columns) Wabash Cannonball Bike Trail, Lucas Co. Ohio B. Proshek; *P. diminutor diminutor* (#9 in upper right & #10) same locale; *P.* probably *diminutor* (#11 Ionia Co. Mich., #12 in lower right Montcalm Co. Mich.).

***Phyciodes tharos tharos***. This species is distinguished by black antenna club nudum, smaller size, orangish unicolorous upf, uph with more or less a postmedian line across the orange central area, unf with median posterior black spot small, and unh with the brown patch dark but thinner than *P. cocyta*. Females may be darker on upf than males. The whitish crescent is lacking in the unh brown patch on most males but is present on most females. Variation occurs in all these traits, but the following specimens (**fig. 6 #1-8**) are obviously *P. tharos*. Specimens:

Wabash Cannonball Bike Trail, S Branch 0.1-0.3 mi. E of Black Road, Lucas Co. Ohio June 29 2006 B. Proshek (0.1 mi E 132m; 0.2 mi E 133*m 134*m; 0.3 mi. E 135*m).

Wabash Cannonball Bike Trail (S Branch) at Black Road, Lucas Co. Ohio June 30 2006 B. Proshek (137*m 139m 140m 141f).

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