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Owen A. Perkins

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USING DEGREE-DAY METHODOLOGY TO ASCERTAIN EARLY FLIGHT PERIODS OF MICHIGAN BUTTERFLIES AND SKIPPERS

Owen A. Perkins¹

ABSTRACT

Butterflies and skippers have been collected in Michigan for over 130 years and the accompanying data labels continue to provide significant information. Both collection date and site information for voucher specimens provide the data that is used to ascertain the daily maximum-minimum temperatures for the year in which the specimens were collected. This information may then be used to calculate the degree-day accumulations above a base value over those specific dates.

The Michigan Entomological Society - Michigan Lepidoptera Survey (MLS) is a team of lepidopterists who have endeavored to create a composite database of all voucher specimens in museum and private collections, published data, and submitted data, as well as from surveys conducted throughout the state. This composite data set was used to formulate a first generation of early flight periods of Michigan butterflies and skippers. Accumulated degree-days for predicting the emergence/dispersal and thus the first early flight period are presented for Michigan butterfly and skipper species and subspecies.

Elements that led to the accumulation of data used to ascertain the growing degree-day values (commonly abbreviated as: degree-day, degday and DD) for each of the Michigan butterfly and skipper populations illustrate the value provided by avocation lepidopterists to the field of entomology. Degree-day is a measure of accumulated heat that can be assigned to each day. Daily values are added together to give an estimate of the amount of development plants, and in this case Lepidoptera, have achieved. The data used in this paper were obtained primarily from the information avocation collectors published or recorded on individual insect labels or in field notes.

Many collectors have traveled from the Lower Peninsula of Michigan to, and across, the Upper Peninsula to collect butterflies, skippers, and moths. They did this only to find the species had not yet emerged or the flight period, sometimes as short as only a few days, had passed for the season and thus for the year.

About 30 years ago it was discovered by Harry D. King (MLS, personal communication) that he could use a correlation between emergence of the adult stage in Michigan from whatever the over-wintering stage might be (egg, larva, pupa, or adult) and the degree-day accumulation from 1 March of that year. He first used this method for the bog-obligate tundra butterfly, *Freija fritillaria*, *Boloria freija freija*, (Thunberg, 1791) (Nymphalidae). Common names used in this paper, though not necessarily approved by the Entomological Society of America, are commonly used by lepidopterists.

The project to determine the early flight period emergence/dispersal date and degree-day value for all of the butterfly and skipper species of Michigan was initiated on 12 July 1997 with the capture of a Poweshiek Skipperling, *Oarisma poweshiek* (Parker, 1870) (Hesperiidae) (Fig. 1). The degree-day information was used to predict subsequent early flight presence of this species in succeeding years.

¹Lepidoptera Alert a.k.a. Lepalert, 2806 Linwood Avenue, Royal Oak, MI 48073-3023. (e-mail: lepalert@comcast.net).



Figure 1. Resident skipper: Poweshiek Skipperling, *Oarsima poweshiek* (Parker, 1870), 8 July 2007, MNA Big Valley Plant Preserve, Buckhorn fen, Rose Township, Oakland County, MI (photo courtesy of Dwayne R. Badgero).

It is difficult to predict plant growth based on calendar date because temperature controls development rate and can vary greatly from month to month and year to year. Instead, degree-days, that are based on actual temperatures, are a simple and accurate way to predict when a certain plant stage will occur. This approach also applies to Lepidoptera. Warmer-than-normal days advance insects' growth more rapidly, while cooler-than-normal days slows growth compared to average. The resulting "thermal time" more consistently predicts when a certain insect stage will occur. One degree-day is one day when the average daily temperature is one degree above the lower developmental threshold (the temperature below which development stops).

Each developmental stage of an organism has its own total heat requirement. Development can be estimated by accumulating degree-days between the daily high and low temperature thresholds throughout the season. The date to begin accumulating degree-days, known as the biofix date, varies with the species. The biofix date used in this examination has usually been 1 March as it is this time of year that the 50° F (10° C) threshold becomes more constant. Tracking degree-days becomes more vital as the accumulation approaches the degree-day base 50° F value (hereafter referred to as DD50) required for the emergence of the specific species. The DD50 value is used because Maize is a facultative long-night plant and flowers in a certain number of growing degree-days > 50° F in the environment to which it is adapted. The MSU Agricultural Weather Office publishes the values for Maize in terms of DD50 (MSU AWO 2008). The use of the DD50 values has been shown to be effective in arriving at the DD50 value for the emergence of Lepidoptera in the adult stage.

MATERIALS AND METHODS

A database of dates of earliest collection for each species was developed using data from a collection of voucher specimens, research of collections in the public and private domain, photographic evidence, and capture and release in the field.

Raw data for the degree-day calculation for each species consisted of the earliest dates recorded for each species in the MLS secondary database kept by the author. There were more than 21,000 unique observations for all Michigan lepidopteran species. Earlier dates have been published for a few species in Nielsen (1999) but the years for these were not provided so the earliest dates that included the year were used.

Daily DD50 values for subject dates were obtained from the MSU AWO website (MSU AWO 2008). When the DD50 values were not available from the MSU AWO source, daily maximum and minimum air temperatures from the NOAA (2005) weather station nearest to each location were used to calculate degree-day accumulations when available. When NOAA data were not available, the data were obtained by an alternative source, such as personal records.

Degree-days were calculated above a base of 50° F (DD50) for each observation using the Baskerville-Emin sine method (Baskerville and Emin 1969, Andresen and Harman 1994, Jeffrey A. Andresen, Department of Geography, Michigan State University, personal communication).

Temperature data for the analysis were also obtained from maximum-minimum daily temperatures by recording maximum-minimum daily degrees using a HOBO recording instrument (The HOBO Data Logger Company, Pocasset, MA). The HOBO Temp data logger is a small, portable, reusable single channel temperature recorder that continuously measures temperature and can be set out in remote locations. The validity of using nearby stations for the actual values at the collecting site was tested in 2003. A HOBO recorder was placed in the field 17 April in Luce County at the west bog field site west of Luce County Road 421 where *Boloria frigga saga* (Staudinger) (Nymphalidae) and *Boloria eunomia dawsoni* (W. Barnes & McDunnough) are always found in good number at the peak of their flight season. There was still snow on the road and in the bog and the temperatures in the Upper Peninsula had not yet reached 50° F. The HOBO was retrieved after favorable peak collecting for *B. f. saga* on 8 June 2003 and indicated a DD50 value of 248. Similarly the MSU Newberry station showed the DD50 as 248 in 2004 for 8 June 2003 indicating that in this particular case using the MSU Newberry station data was a reliable method. The recorded DD50 reported by MSU for 8 June 2003 in 2003 for the Newberry station, however, was given as 233.

The discrepancy in the value reported in different years likely arose because although stations are supposed to take a reading every day and send it into MSU, occasionally data are not reported and a value based on the average of 30 years data is substituted. At the end of the year a hard copy is sent to MSU Agricultural Weather Office and adjustments are made to show the actual readings which generally differ by 10-15° F from the estimated value (King, personal communication). Warm years can be deceptive because degree-days accumulate faster than the insect can respond with faster development (i.e., growth rate is already maximized) thus it results in the appearance of a flight time that is delayed and longer than normal in terms of degree-days.

RESULTS AND DISCUSSION

The results of accumulating the earliest flight period date and the corresponding DD50 values for that date and site for each butterfly and skipper species are provided in Table 1.

Table 1. Accumulated Degree-days above 50°F for the early light period emergence/dispersal of Michigan butterfly and skipper species and subspecies.

Scientific name ^a	Collector	MLS Early Date ^b	County	DD50F	Flight ^c
HESPERIIDAE					
<i>Epagyreuus clarus clarus</i> (Cramer)	Kuhlman, Roger	2 May 1999	Washtenaw	170	R
<i>Urbanus proteus</i> (Linnaeus)	Newcomb, William W.	Prior 1913	Wayne	N/A	S
<i>Achalarus lyciades</i> (Geyer)	Kuhlman, Roger	9 May 2001	Washtenaw	286	R
<i>Thorybes bathyllus</i> (J. E. Smith)	Moore, Sherman	5 May 1941	Livingston	193	R
<i>Thorybes pylades pylades</i> (Scudder)	Perkins, Owen A.	12 May 2000 *	Washtenaw	320	R
<i>Pholisora catullus</i> (Fabricius)	Perkins, Owen A.	5 May 2000 *	Cass	202	R
<i>Erynnis icelus</i> (Scudder & Burgess)	Perkins, Owen A.	24 Apr 1998	Oakland	157	R
<i>Erynnis brizo</i> (Boisduval & Le Conte)	Kuhlman, Roger	18 Apr 2000	Washtenaw	96	R
<i>Erynnis juvenalis juvenalis</i> (Fabricius)	Perkins, Owen A.	20 Apr 1998	Oakland	140	R
<i>Erynnis horatius</i> (Scudder & Burgess)	Kuhlman, Roger	29 Apr 2000	Washtenaw	140	R
<i>Erynnis marialis</i> (Scudder)	Perkins, Owen A.	13 May 1951	Calhoun	178	R
<i>Erynnis funeralis</i> (Scudder & Burgess)	Granlund, James L.	18 Aug 2001	Chippewa	1454	S
<i>Erynnis baptisiae</i> (W. Forbes)	Bialecki, Martin J.	22 Apr 2006	Monroe	152	R
<i>Erynnis lucilius</i> (Scudder & Burgess)	Perkins, Owen A.	5 May 2000	Monroe	197	R
<i>Erynnis persius persius</i> (Scudder) (1 st brood)	Oosting Daniel S.	1 May 1976	Allegan	169	R
<i>Erynnis persius persius</i> (Scudder) (2 nd brood)	Perkins, Owen A.	8 Jul 2007	Oakland	1189	R
<i>Pyrgus centaureae wyandot</i> (W. H. Edwards)	Nielsen, Mogens C.	3 May 1981	Montcalm	151	R
<i>Pyrgus communis communis</i> (Grote)	Farmer, John C.	9 Apr 2004	Hillsdale	55	R
<i>Carterocephalus palaemon mandan</i> (W. H. Edwards)	Perkins, Owen A.	15 May 1998	Schoolcraft	135	R
<i>Ancylorhiza numitor</i> (Fabricius)	Farmer, John C.	9 Apr 2004	Hillsdale	55	R
<i>Oarisma poweshiek</i> (Parker)	Newcomb, William W.	9 Jun 1930	Kent	789	R
<i>Oarisma poweshiek</i> (Parker) emended	Perkins, Owen A.	22 Jun 1998	Oakland	849	R
<i>Thymelicus lineola lineola</i> (Ochsenheimer)	Perkins, Owen A.	1 Jun 1998 *	Oakland	605	R
<i>Calpodus ethlius</i> (Stoll)	Weaver, Scott	29 May 1999	Jackson	475	S
<i>Panoquina ocola ocola</i> (W. H. Edwards)	Kuhlman, Roger	2 Oct 2005	Monroe	2985	S
<i>Amblyscirtes hegona</i> (Scudder)	Kuhlman, Roger	24 May 2007 *	Livingston	390	R
<i>Amblyscirtes vialis</i> (W. H. Edwards)	Herrig, Terry L.	5 May 2000	Cass	202	R
<i>Nastra lherminier</i> (Latreille)	Koehn, Larry C.	17 Jul 1983	Cass	1373	S
<i>Lerodes eufata eufata</i> (W. H. Edwards)	Dreisbach, Robert R.	25 Aug 1959	Ontonagon	1408	S

Table 1. Continued.

Scientific name ^a	Collector	MLS Early Date ^b	County	DD50F	Flight ^c
<i>Lerema accius</i> (J. E. Smith)	Herig, Terry L.	4 Sep 1998	Lenawee	2656	S
<i>Hylephila phyleus phyleus</i> (Drury)	Kuhlman, Roger	14 Jun 1999	Washtenaw	826	M
<i>Hesperia comma laurentina</i> (Lyman)	Johnson, Kyle E.	27 Jul 2003 *	Delta	1065	R
<i>Hesperia otloe</i> (W. H. Edwards)	Balogh, George J.	1 Jun 1987	Allegan	663	R
<i>Hesperia leonardus leonardus</i> (T. Harris)	Newcomb, William W.	3 Jul 1930	Dickinson	742	R
<i>Hesperia metea metea</i> Scudder	Perkins, Owen A.	5 May 2000	Allegan	202	R
<i>Hesperia sassacus sassacus</i> (T. Harris)	Perkins, Owen A.	29 May 1999 *	Arenac	357	R
<i>Polites peckius peckius</i> (W. Kirby)	Holzman, Richard W.	7 Apr 1958	Livingston	21	R
<i>Polites themistocles themistocles</i> (Latreille)	Warczynski, Virgil J.	11 May 1963	Lapeer	201	R
<i>Polites origenes origenes</i> (Fabricius)	Kuhlman, Roger	16 Jun 2002 *	Washtenaw	633	R
<i>Polites mystic mystic</i> (W. H. Edwards)	Warczynski, Virgil J.	5 May 1962	Arenac	131	R
<i>Wallengrenia egeremet</i> (Scudder)	Moore, Sherman	8 Jun 1939	Livingston	540	R
<i>Pompeius verna</i> (W. H. Edwards)	Reinoehl, Jack	4 Jun 2004	Gratiot	519	R
<i>Atalopodes campestris huron</i> (W. H. Edwards)	unknown	15 Sep 1999 *	Washtenaw	2650	S
<i>Poanes hobomok hobomok</i> (T. Harris)	Kuhlman, Roger	12 May 2000	Washtenaw	320	R
<i>Poanes zabulon</i> (Boisduval & Le Conte)	Nielsen, Mogens C.	28 May 1989	St. Joseph	502	R
<i>Poanes massasoit massasoit</i> (Scudder)	Moody, Philip E.	29 May 1938	Oakland	344	R
<i>Poanes viator viator</i> (W. H. Edwards)	Reinoehl, Jack	28 Jun 2007	Gratiot	1133	R
<i>Anatrytone logan logan</i> (W. H. Edwards)	Kuhlman, Roger	17 Jun 2001 *	Washtenaw	765	R
<i>Euphyes conspiciua conspiciua</i> (W. H. Edwards)	Warczynski, Virgil J.	6 Jun 1962	Lapeer	610	R
<i>Euphyes dion</i> (W. H. Edwards)	Warczynski, Virgil J.	17 Jun 1963	Saginaw	777	R
<i>Euphyes dukesi dukesi</i> (Lindsey)	Kleitch (Fettingner), Jennifer	5 Jun 2003	Muskegon	501	R
<i>Euphyes bimacula bimacula</i> (Grote & Robinson)	Wagner, Warren H. Jr.	4 Jun 1956	Washtenaw	311	R
<i>Euphyes vestris metacomet</i> (T. Harris)	Leski, Michael L.	29 May 2006	Ontonagon	302	R
<i>Atrytonopsis hianna hianna</i> (Scudder)	Hodges, Ronald W.	21 May 1958	Crawford	183	R
PAPILIONIDAE					
<i>Battus philenor philenor</i> (Linnaeus) (1 st brood)	Warczynski, Virgil J.	20 Apr 1966	Lenawee	155	R
<i>Battus philenor philenor</i> (Linnaeus) (2 nd brood)	Churchill, Mark	6 Jul 2008	Allegan	926	R
<i>Eurytides marcellus</i> (Cramer) (1 st brood)	Nielsen, Mogens C.	28 Apr 1955	Berrien	175	R

Table 1. Continued.

Scientific name ^a	Collector	MLS Early Date ^b	County	DD50F	Flight ^c
<i>Eurytides marcellus</i> (Cramer) (2 nd brood)	Hubbell, Theodore H.	26 Jun 1919	Berrien	898	R
<i>Papilio machaon hudsonianus</i> A. Clark	Bogar, Daniel S.	9 Jun 1991	Chippewa	533	S
<i>Papilio polyxenes asterius</i> (Stoll) (1 st -brood)	Starkey, Donald J.	14 Apr 1997 *	Macomb	54	R
<i>Papilio polyxenes asterius</i> (Stoll) (2 nd -brood)	Perkins, Owen A.	16 Jun 1951	Oakland	630	R
<i>Papilio cresphontes</i> Cramer (1 st brood)	Bess, James A.	25 Apr 1983	Jackson	168	R
<i>Papilio cresphontes</i> Cramer (2 nd brood)	Perkins, Owen A.	22 Jun 1997	Oakland	637	R
<i>Papilio canadensis</i> Rothschild & Jordan	Nielsen, Mogens C.	28 Apr 2000	Otsego	83	R
<i>Papilio glaucus glaucus</i> Linnaeus	Bialecki, Martin J.	15 Apr 2000	Washtenaw	84	R
<i>Papilio troilus troilus</i> Linnaeus (1 st brood)	unknown	22 Apr 1914	Ingham	134	R
<i>Papilio troilus troilus</i> Linnaeus (2 nd brood)	Legge, John T.	12 Jul 1994	Kalamazoo	1255	R
PIERIDAE					
<i>Nathalis iole</i> Boisduval	Ross, Stephen	18 Jul 2001	Gogebic	1068	M/R
<i>Eurema mexicana mexicana</i> (Boisduval)	Grocoff, M.	7 Jun 1977	Livingston	874	S
<i>Pyrsitia lisa lisa</i> (Boisduval & Le Conte)	unknown	15 May 1964	Ingham	200	M/R
<i>Abaeis nicippe</i> (Cramer)	Deering, Mark	20 Jun 1996	Kalamazoo	750	S
<i>Colias philodice philodice</i> Godart	Yates, Arthur A.	4 Apr 1943	Presque Isle	101	R
<i>Colias interior</i> Scudder	Bialecki, Martin J.	22 Apr 2006 *	Monroe	152	R
<i>Zerene cesonia cesonia</i> (Stoll)	Perkins, Owen A.	20 Jun 1998 *	Otsego	653	R
<i>Phoebis sennae sennae</i> = <i>eubule</i> (Linnaeus)	Newman, John W.	23 May 1939	Oakland	239	S
<i>Phoebis philea philea</i> (Linnaeus)	Farmer, John C.	21 May 1999	Washtenaw	390	M/R
<i>Euchloe ausonides mayi</i> F. Chermock & R. Chermock	Beebe, Ralph	25 Aug 1951	Wayne	2412	S
<i>Euchloe olympia</i> = <i>rosa</i> (W. H. Edwards)	Nielsen, Mogens C.	11 May 1987	Keweenaw	46	R
<i>Pieris oleracea oleracea</i> (T. Harris) (1 st brood)	Nielsen, Mogens C.	23 Apr 1955	Berrien	152	R
<i>Pieris oleracea oleracea</i> (T. Harris) (2 nd brood)	Kuhlman, Roger	11 Apr 1998	Washtenaw	107	R
<i>Pieris virginianus virginianus</i> W. H. Edwards	McAlpine, Wilbur S.	21 Jun 1936	Cass	700	R
<i>Pieris rapae rapae</i> (Linnaeus)	Nielsen, Mogens C.	24 Apr 1990	Cass	145	R
<i>Pontia protodice</i> (Boisduval & Le Conte)	Kuhlman, Roger	23 Mar 2000	Washtenaw	40	R
<i>Pontia occidentalis occidentalis</i> (Reakirt)	Wagner, Warren H. Jr.	18 Apr 1981 *	St. Joseph	133	R
<i>Ascia monuste phileta</i> (Fabricius)	Nielsen, Mogens C.	19 Jun 1989	Montcalm	917	S
	Monnier, Francis X.	N/A	N/A	N/A	S

Table 1. Continued.

Scientific name ^a	Collector	MLS Early Date ^b	County	DD50F	Flight ^c
LYCAENIDAE					
<i>Feniseca tarquinus tarquinus</i> (Fabricius)	Kuhlman, Roger	26 Apr 2000	Washtenaw	124	R
<i>Lycæna phlaeas hypophylaeas = americana</i> T. Harris	Kuhlman, Roger	1 May 1999 *	Washtenaw	162	R
<i>Lycæna hylthus</i> (Cramer)	McKenney, M. J.	25 Apr 1962	Livingston	68	R
<i>Lycæna epixanthe michiganensis</i> Rawson	Newman, John W.	4 Jun 1946	Oakland	407	R
<i>Lycæna dorcas michuron</i> Scott	Smith, Todd	6 Jul 2007	Oakland	1144	R
<i>Lycæna dorcas dorcas</i> W. Kirby	Fischer, Ronald L.	10 Jun 1959	Barry	701	R
<i>Lycæna helioides</i> (Boisduval)	Hodges, Ronald W.	14 May 1955	Montcalm	300	R
<i>Satyrum acadica acadica</i> (W. H. Edwards)	McKenney, M. J.	25 Apr 1962	Livingston	68	R
<i>Satyrum titus titus</i> (Fabricius)	McKenney, M. J.	25 Apr 1962	Livingston	68	R
<i>Satyrum edwardsii edwardsii</i> (Grote & Robinson)	Nielsen, Mogens C.	10 Jun 2004	Newaygo	563	R
<i>Satyrum calanus falacer</i> (Godart)	Nielsen, Mogens C.	25 Apr 1952	Livingston	148	R
<i>Satyrum caryaevorus</i> (McDunnough)	McKenney, M. J.	25 Apr 1962	Livingston	68	R
<i>Satyrum liparops strigosa</i> (T. Harris)	Newman, John H.	3 Jun 1944	Wexford	247	R
<i>Satyrum favonius ontario</i> (W. H. Edwards)	Oosting Daniel S.	28 Jun 1975	Lenawee	930	S
<i>Calliphrys augustinus augustinus</i> (Westwood)	Kuhlman, Roger	14 Apr 2003	Washtenaw	88	R
<i>Calliphrys polios polios</i> (Cook & F. Watson)	Perkins, Owen A.	27 Apr 2000 *	Chippewa	49	R
<i>Calliphrys irus irus</i> (Godart)	Nielsen, Mogens C.	25 Apr 1987	Allegan	243	R
<i>Calliphrys henrici henrici</i> (Grote & Robinson)	Nielsen, Mogens C.	28 Apr 1981	Montcalm	154	R
<i>Calliphrys niphon clarki</i> (T. Freeman)	Warczynski, Virgil J.	18 Apr 1968	Arenac	102	R
<i>Calliphrys eryphon eryphon</i> (Boisduval)	Perkins, Owen A.	27 Apr 2000	Chippewa	49	R
<i>Calyceps cecrops</i> (Fabricius)	Monnier, Francis X.	10 Jul 1882	Berrien	N/A	S
<i>Strymon melinus humuli</i> (T. Harris)	Nielsen, Mogens C.	23 Apr 1955	Berrien	152	R
<i>Parrhasius m-album</i> (Boisduval & Le Conte)	Taggart, John	12 Aug 1964	Muskegon	2017	S
<i>Erora laeta</i> (W. H. Edwards) (1 st brood)	Elsner, Elwin A.	9 May 1998	Leelanau	122	R
<i>Erora laeta</i> (W. H. Edwards) (2 nd brood)	Oosting, Daniel S.	21 Jul 1981	Emmet	909	R
<i>Cupido comyntas comyntas</i> (Godart)	Bialecki, Martin J.	22 Apr 2006	Monroe	152	R
<i>Cupido amynthula amynthula</i> (Boisduval)	Moore, Sherman	3 May 1920	Mackinac	43	M/R
<i>Celastrina lucia lucia</i> (W. Kirby)	Bess, James A.	18 Apr 1987	Otsego	81	R
<i>Celastrina ladon</i> (Cramer)	Kuhlman, Roger	1 Apr 2000	Washtenaw	63	R

Table 1. Continued.

Scientific name ^a	Collector	MLS Early Date ^b	County	DD50F	Flight ^c
<i>Celastrina serotina</i> Pavulan & D. Wright	Heng Jr., Edward	1 May 2006	Clinton	170	R
<i>Celastrina neglecta</i> (W. H. Edwards)	Stinson, Walter C.	31 May 1930	Washtenaw	400	R
<i>Glaucopsyche lygdamus couperti</i> Grote	Hodges, Ronald W.	30 Apr 1965	Montcalm	134	R
<i>Echinargus isola</i> (Reakirt)	Swales, John	29 May 1996	Washtenaw	330	M/R
<i>Plebejus idas nabokovi</i> (Masters)	Nielsen, Mogens C.	3 Jun 1987	Alger	149	R
<i>Plebejus melissa samuelis</i> (Nabokov) (1 st brood)	Heng Jr., Edward	5 May 1989	Allegan	213	R
<i>Plebejus melissa samuelis</i> (Nabokov) (2 nd brood)	Oosting, Daniel S.	22 Jun 1982	Allegan	681	R
<i>Plebejus melissa samuelis</i> (Nabokov) (peak)	Perkins, Owen A.	7 Jul 2007	Montcalm	1325	R
<i>Plebejus saepiolus amica</i> (W. H. Edwards)	Newman, John W.	20 May 1941	Oscoda	134	R
RIODINIDAE					
<i>Catophtelis muticum</i> McAlpine	Wagner, Warren H. Jr.	21 Jun 1954	Washtenaw	992	R
NYMPHALIDAE					
<i>Libytheana carinenta bachmanii</i> Kirtland	Oosting, Daniel S.	1 Jun 1970	Ottawa	390	M
<i>Danaus plexippus plexippus</i> (Linnaeus)	Bialecki, Martin J.	21 Apr 2006	Washtenaw	130	M/R
<i>Danaus gilippus berenice</i> (Cramer)	Kuhlman, Roger	17 Jul 2003	Washtenaw	1277	S
<i>Limenitis arthemis arthemis</i> (Drury)	unknown	21 May 1902	Alger	N/A	R
<i>Limenitis arthemis arthemis</i> (Drury)	Leski, Michael L.	14 Jun 1964	Marquette	418	R
<i>Limenitis arthemis = proserpina</i> W. H. Edwards	Newman, John H.	29 May 2006	Ontonagon	302	R
<i>Limenitis arthemis = albofasciata</i> Newcomb	Perkins, Owen A.	16 Jun 1944	Oscoda	348	R
<i>Limenitis a. rubrofasciata</i> (Barnes & McDunnough)	Kuhlman, Roger	17 Aug 1999	Mackinac	1300	R
<i>Limenitis arthemis astyanax</i> (Fabricius)	Kuhlman, Roger	19 May 1998	Washtenaw	473	R
<i>Agraulis vanillae nigrior</i> Michener	Kuhlman, Roger	19 May 2001	Washtenaw	397	R
<i>Euptoieta claudia</i> (Cramer)	Kuhlman, Roger	21 Jul 1998	Washtenaw	1881	S
<i>Boloria eunomia dawsoni</i> (W. Barnes & McDunnough)	Kuhlman, Roger	26 Apr 2004	Washtenaw	176	M/R
<i>Boloria selene myrina</i> (Cramer)	Perkins, Owen A.	27 May 1998	Chippewa	322	R
<i>Boloria selene atrostaltis</i> (Huard)	Warczynski, Virgil J.	4 May 1962	Bay	123	R
<i>Boloria bellona bellona</i> (Fabricius)	Perkins, Owen A.	15 May 1998	Schoolcraft	135	R
	Kuhlman, Roger	25 Apr 1999	Washtenaw	120	R

Table 1. Continued.

Scientific name ^a	Collector	MLS Early Date ^b	County	DD50F	Flight ^c
<i>Boloria frigga saga</i> (Staudinger)	Perkins, Owen A.	15 May 1998	Luce	135	R
<i>Boloria freija freija</i> (Thunberg)	Perkins, Owen A.	9 May 1998 *	Dickinson	81	R
<i>Speyeria cybele cybele</i> (Fabricius)	Kuhlman, Roger	20 May 1998	Washtenaw	496	R
<i>Speyeria cybele kratuurni</i> (W. Holland)	Unknown	25 Jun 1910 *	Alger	902	R
<i>Speyeria aphrodite aphrodite</i> (Fabricius)	Martinat, Peter J.	6 Jun 1974	Allegan	665	R
<i>Speyeria aphrodite alcestis</i> (W. H. Edwards)	Perkins, Owen A.	3 Jul 2000	Barry	942	R
<i>Speyeria italica italica</i> (Drury)	King, Harry D.	25 Jun 1977 *	St. Joseph	1199	R
<i>Speyeria atlantis atlantis</i> (W. H. Edwards)	Warczynski, Virgil J.	26 May 1963	Otsego	218	R
<i>Asterocampa cellis cellis</i> (Boisduval & Le Conte)	Kuhlman, Roger	2 Jun 2007	Washtenaw	620	R
<i>Asterocampa clyton clyton</i> (Boisduval & Le Conte)	King, Harry D.	30 May 1977	Barry	550	R
<i>Vanessa virginiensis</i> (Drury)	Kuhlman, Roger	8 Apr 2001	Washtenaw	0	R
<i>Vanessa cardui</i> (Linnaeus)	Ross, Stephen	18 Apr 2005	Mecosta	112	M/R
<i>Vanessa atalanta rubria</i> (Fruhstorfer)	Kuhlman, Roger	5 Apr 1998	Washtenaw	99	M/R
<i>Aglais milberti milberti</i> (Godart)	Kuhlman, Roger	5 Mar 2000	Washtenaw	0	R
<i>Nymphalis l-album j-album</i> (Boisduval & Le Conte)	Kuhlman, Roger	12 Mar 2002	Washtenaw	0	R
<i>Nymphalis californica</i> (Boisduval)	Voss, Edward G.	4 Sep 1945	Emmet/Mason	1835	S
<i>Nymphalis antiopa antiopa</i> (Linnaeus)	Kuhlman, Roger	28 Feb 2004	Washtenaw	2	R
<i>Polygonia interrogatoris</i> (Fabricius)	Perkins, Owen A.	9 Jun 1969	Oakland	468	R
<i>Polygonia interrogatoris = umbrosa</i> (Lintner)	Kuhlman, Roger	14 Apr 2003	Washtenaw	88	R
<i>Polygonia comma comma</i> (T. Harris)	Perkins, Owen A.	28 Feb 1998	Oakland	7	R
<i>Polygonia comma = dryas</i> (W. H. Edwards)	Bess, James A.	19 Apr 1980	Jackson	139	R
<i>Polygonia satyrus neomarsyas</i> dos Passos	Nielsen, Mogens C.	17 May 2001 *	Iron	218	R
<i>Polygonia progné</i> (Cramer)	Perkins, Owen A.	7 Mar 2000	Oakland	32	R
<i>Polygonia progné = l-argenteum</i> Scudder	Donahue, Julian P.	11 Apr 1964	Ingham	24	R
<i>Polygonia gracilis gracilis</i> (Grote & Robinson)	Nielsen, Mogens C.	29 May 1960	Schoolcraft	178	R
<i>Polygonia faunus faunus</i> (W. H. Edwards)	Donahue, Julian P.	30 Mar 1944	Otsego	0	R
<i>Junonia coenia coenia</i> (Hubner)	Kuhlman, Roger	12 May 2000	Washtenaw	320	M/R
<i>Junonia coenia = rosa</i> (Whittaker & D. Stallings)	Nielsen, Mogens C.	17 Sep 2002	Cass	2700	M/R
<i>Junonia genoveva</i> (Cramer)	Knight, Ken	20 Oct 2007	Kent	3155	S
<i>Euphydryas phaeton phaeton</i> (Drury)	King, Harry D.	28 May 1995 *	Ingham	465	R

Table 1. Continued.

Scientific name ^a	Collector	MLS Early Date ^b	County	DD50F	Flight ^c
<i>Chlosyne nycteis nycteis</i> (E. Doubleday)	McKenney, M. J.	25 Apr 1962	Livingston	68	R
<i>Chlosyne gorgone carlota</i> (Reakirt)	Gaige, Frederick M.	26 May 1934	Iosco	221	R
<i>Chlosyne harrisi harrisi</i> (Scudder)	Perkins, Owen A.	1 Jun 1998	Oakland	605	R
<i>Phyciodes tharos tharos</i> (Drury)	McKenney, M. J.	25 Apr 1962	Livingston	68	R
<i>Phyciodes cocyta selentis</i> (W. Kirby)	Cuthrell, David L.	30 Apr 1995	Keweenaw	37	R
<i>Phyciodes batesii batesii</i> (Reakirt)	McAlpine, Wilbur S.	4 May 1941 *	Montmorency	101	R
<i>Anaea andria</i> Scudder	Stinson, Walter C.	8 May 1932	Washtenaw	206	S
<i>Letho anthedon anthedon</i> A. Clark	Starkey, Donald J.	18 Jun 1998	Macomb	807	R
<i>Letho anthedon borealis</i> A. Clark	Perkins, Owen A.	22 Jun 2007	Alger	610	R
<i>Letho creola</i> (Skinner)	Bruce, David	N/A	N/A	N/A	S
<i>Letho eurydice eurydice</i> (Linnaeus)	Ex, Jacob C.	25 May 2005	Oakland	303	R
<i>Letho appalachia leeuwi</i> Gatrell & Arbogast	Starkey, Donald J.	14 Jun 1998	Oakland	779	R
<i>Coenonympha tullia inornata</i> W. H. Edwards	Katz, Steve	28 May 2007	Oakland	458	R
<i>Neonympha mitchellii mitchellii</i> French	Harvey, Donald J.	14 Jun 1974	Jackson	580	R
<i>Megisto cymela cymela</i> (Cramer)	Kuhlman, Roger	16 May 1998 *	Washtenaw	409	R
<i>Cercyonis pegala alope</i> (Fabricius)	Hunter, James	1 Jun 1978	Oakland	518	R
<i>Cercyonis pegala nephele</i> (W. Kirby)	Unknown	7 Jun 1940	Ingham	639	R
<i>Erebia discoidalis discoidalis</i> (W. Kirby)	Badgero, Dwayne R.	3 May 2007	Chippewa	76	R
<i>Oeneis jutta ascerta</i> Masters & Sorenson	Ross, Stephen	20 May 2006	Delta	158	R
<i>Oeneis chryxus strigulosa</i> McDunnough	King, Harry D.	2 May 1999	Newaygo	143	R
<i>Oeneis macounii</i> (W. H. Edwards)	Nielsen, Mogens C.	16 Jun 1986	Keweenaw	431	R

^a Arrangement by Pelham et al. (2008).

^b MLS is Michigan Lepidoptera Survey data.

^c Flight key is: R=Resident, M=Migrant, M/R=Migrant/Resident, S=Stray.

* Early date data does not have year provided, therefore alternate early date with year is used.

Although insect phenology modeling using degree days is a common strategy for managing agricultural pests, it is rarely used to predict the phenology of threatened or endangered insects. The present study describes an analytical method using historical records that produces a phenological model adequate for conducting field surveys of some insect species (Robert D. Kriegel and Mogens C. Nielsen, Michigan State University, personal communication).

It is important to also ascertain the peak flight period as it may be derived from the data used to determine the early flight period date and documented observations of large explosive emergences. This has been done to some extent for the Federally Endangered Karner Blue *Plebejus melissa samuelis* (Nabokov, 1944) (Lycaenidae) (Nielsen 1999; Fig. 2).

The degree-day predictions for Karner Blue emergence were tested in 2007. On 7 July 2007 a team of MLS members and others encountered a peak emergence of Karner Blue while surveying in Montcalm County at a site where the larval host plant, lupine, *Lupinus perennis* L., was previously observed in bloom in May. After the emergence in May of the first brood of the Karner Blue that was also observed, the team returned to the site where spotted knapweed, *Centaurea maculosa* Lam., was then in full bloom, serving as a nectar source. Approximately 2,000-3,000 Karner Blue butterflies were observed in a 1/3 acre (0.1349 ha) area. The calculated DD50 was 1331.

It was the Poweshiek Skipperling, *O. poweshiek* (Fig. 1) that led the author to the realization that degree-days would be a valuable tool in determining the emergence date of a species especially in historically-active sites. On 10 July 1997, the author traveled to an historically-active site discovered by Richard W. Holzman (Past-President, Michigan Nature Association (MNA), personal



Figure 2. Resident butterfly: Karner Blue, *Plebejus melissa samuelis* (Nabokov, 1944), 7 July 2007, Gates Road power-line, Reynolds Township, Montcalm County, MI, Manistee National Forest (photo courtesy of Todd Smith).

communication) at Rattalee Lake Road, Oakland County, where the author's first collection of the species occurred. In subsequent years as a member of MNA voucher specimens were collected on the MNA Clifford R. & Calla C. Burr Memorial Plant Preserve, contiguous to the Rattalee Lake Road site. On 29 June 1998 the author collected a voucher specimen at the MNA Big Valley Plant Preserve, Buckhorn Lake fen in Oakland County for a new site record. Using the degree-day values accumulated, the author pursued the species at an earlier DD value. On 22 June 2000 with a DD50 value of 848 at the nearby Milford weather station, a voucher specimen was collected at the MNA Burr Plant Preserve for the earliest day of the year flight period and the lowest accurate DD50 value. This information allows for further explorations at other potential sites and reevaluation of historically-active sites for the continued presence of this Michigan Natural Features Inventory (MNFI) Special Concern species. Degree-days provide information on the optimum early day to start a survey for a species and gives future explorations a more likely chance of specimen capture.

Degree Day counts could also be used to standardize counts of butterflies on one day per year, such as the Fourth of July Butterfly Counts. These kinds of surveys are extensive, however, the data collected from such surveys have not been widely utilized because of the difficulty in interpreting counts in which butterfly abundances appear to fluctuate. Fluctuations are due in part to the timing of when counts were made relative to phenology that is determined in part by growing degree days. The degree day approach could be used to standardize these long-term records across years and make the results useful.

Examples of the Michigan flight dynamics tend to fall into four categories: Resident, Migrant, Resident/Migrant, and Stray. The Michigan species are labeled as such in Table 1. Listed by category are examples of these flight dynamics. Resident species include: Poweshiek Skipperling (Fig. 1); Karner Blue (Fig. 2); Dukes' Skipper, *Euphyes dukesi dukesi* (Lindsey, 1923) (Hesperiidae) (Fig. 3); and Swamp Metalmark, *Calephelis muticum* McAlpine, 1937 (Riodinidae) (Fig. 4). Migrant species include: Snout Butterfly, *Libytheana carinenta bachmanii* (Kirtland, 1851) (Nymphalidae) (Fig. 5); Fiery Skipper, *Hylephila phyleus phyleus* (Drury, 1773) (Hesperiidae) (Fig. 6); and Painted Lady, *Vanessa cardui* (Linnaeus, 1758) (Nymphalidae). Migrant/Resident species include: Monarch, *Danaus plexippus plexippus* (Linnaeus, 1758) (Nymphalidae) (Fig. 7); Cloudless Sulphur, *Phoebis sennae sennae* = *eubule* (Linnaeus, 1767) (Pieridae) (Fig. 8); and Little Sulphur, *Pyrisitia lisa lisa* (Boisduval & Le Conte, 1830) (Pieridae). Strays include: Ocola Skipper, *Panoquina ocola ocola* (W. H. Edwards, 1863) (Hesperiidae) (Fig. 9); Old World Swallowtail, *Papilio machaon hudsonianus* A. Clark; 1932 (Papilionidae); White-M Hairstreak, *Parrhasius m-album* (Boisduval & Le Conte, 1833) (Lycaenidae) (Fig. 10); and Goatweed Butterfly; *Anaea andria* Scudder, 1875 (Nymphalidae).

CONCLUSIONS

I invite interested lepidopterists to use the information provided to determine prior early flight period emergence/dispersal for Michigan butterflies and skippers, and eventually for the moth population. Of course the exact site location, nearby meteorological station, recorded degree-day value, and other pertinent data should be recorded for the species for that date and the new early date and DD50 should be published and/or provided to the Michigan Lepidoptera Survey for inclusion in the primary (Michigan listed species) and secondary (all Michigan species) databases.



Figure 3. Resident skipper: Dukes' Skipper, *Euphyes dukesi dukesi* (Lindsey, 1923), 15 July 2005, Liberty Road fen, Liberty Township, Jackson County, MI (photo courtesy of Chris Rickards).



Figure 4. Resident butterfly: Swamp Metalmark, *Calephelis muticum* McAlpine, 1937, 13 July 2005, Lost Nation State Game Area, Jefferson Township, Hillsdale County, MI (photo courtesy of Dwayne R. Badgero).



Figure 5. Migrant butterfly: Snout Butterfly, *Libytheana carinenta bachmanii* (Kirtland, 1851), 23 July 2005, Crosswinds Marsh, Sumpter Township, Wayne County, MI (photo courtesy of Chris Rickards).



Figure 6. Migrant skipper: Fiery Skipper, *Hylephila phyleus phyleus* (Drury, 1773), 20 August 2005, Gateway Garden, University of Michigan's Matthaei Botanical Gardens, Superior Township, Washtenaw County, MI (photo courtesy of Chris Rickards).

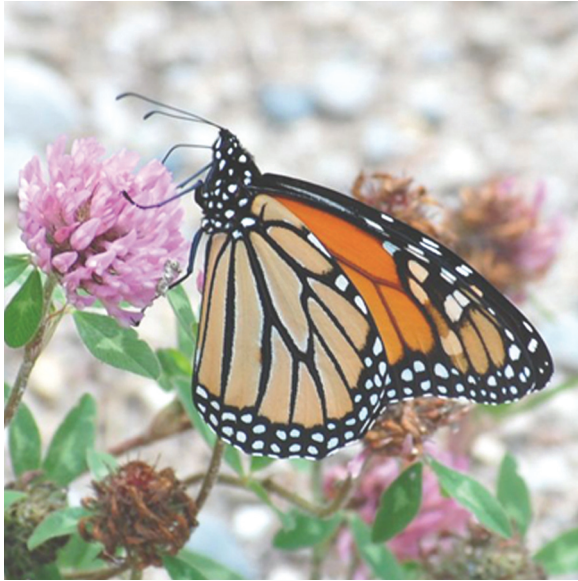


Figure 7. Migrant/Resident butterfly: Monarch, *Danaus plexippus plexippus* (Linnaeus, 1758), 15 July 2007, Greene Road, Moran Township, Mackinac County, MI (photo courtesy of Todd Smith).



Figure 8. Migrant/Resident butterfly: Cloudless Sulphur, *Phoebis sennae sennae* = *eubule* (Linnaeus, 1767), 12 August 2006, Crosswinds Marsh, Sumpter Township, Wayne County, MI (photo courtesy of Chris Rickards).



Figure 9. Stray skipper: Ocola Skipper, *Panoquina ocola ocola* (W. H. Edwards, 1863), collected by Roger Kuhlman, 2 October 2005, Petersburg State Game Area, Summerfield Township, Monroe County, MI (photo courtesy of Ronald Priest and adapted by Owen A. Perkins).



Figure 10. Stray butterfly: White-M Hairstreak, *Parrhasius m-album* (Boisduval & Le Conte, 1833), collected by John Taggart, 12 August 1964, Duck Lake State Park, Fruitland Township, Muskegon County, MI (photo by Owen A. Perkins).

Further investigation as to the peak flight periods and the life history degree-day values for the various species is encouraged.

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LITERATURE CITED

- Andresen, J. A., and J. R. Harman. 1994. Springtime freezes in western Lower Michigan: Climatology and trends, Michigan State University Extension. MSU Extension Vegetable Bulletins - AF089402.
- Baskerville, G. L., and P. Emin. 1969. Rapid estimation of heat accumulation from maximum and minimum temperatures. *Ecology* 50: 514-517.
- (MSU AWO) Michigan State University Agricultural Weather Office. 2008. Growing degree day accumulations. Available at: <<http://www.agweather.geo.msu.edu/AWO/Current/report.asp?fileid=degreeday>>
- Nielsen, M. C. 1999. Michigan Butterflies and Skippers. Michigan State University Extension. East Lansing, Michigan.
- (NOAA) National Oceanic and Atmospheric Administration. 2005. Quality controlled local climatological data. National Climatic Data Center, Asheville, North Carolina. Available at: <<http://cdo.ncdc.noaa.gov/qclcd/QCLCD>>
- Pelham, J. P. 2008. A Catalogue of the Butterflies of the United States and Canada with a complete bibliography of the descriptive and systematic literature. *J. Res. Lep.* vol 40.