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## Variation in Detecting *Schinia Indiana* and *Schinia Lucens* (Lepidoptera: Noctuidae) in Wisconsin


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# VARIATION IN DETECTING *SCHINIA INDIANA* AND *SCHINIA LUCENS* (LEPIDOPTERA: NOCTUIDAE) IN WISCONSIN

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## ABSTRACT

*Schinia indiana* (Smith) and *Schinia lucens* (Morrison) (Lepidoptera: Noctuidae) are diurnal moths and are well camouflaged when perched on flowers of their larval food plants: *Phlox pilosa* L. (Polemoniaceae) and *Amorpha* (Fabaceae), respectively. We recorded 264 *S. indiana* in diurnal surveys of 28 units of 15 sites in Jackson County, WI, and 25 units of 5 sites in Burnett County, WI, from 23 May (2006) to 15 June (1994). The longest flight periods in single years were 21 days in 1994 and 17 days in 2006. Abundance of individuals was significantly greater when phlox flowering was prepeak and peak, compared to earlier and later in phlox flowering phenology. We recorded 46 *S. lucens* in diurnal surveys of nine sites in six counties in southern Wisconsin and two sites in two counties in northwestern Wisconsin, from 30 June (1998) to 29 July (2002). The longest flight periods in single years statewide were 23 days (2002) and 15 days (2000). One *S. indiana* flushed at 16ºC, but all other flushes occurred when it was > 20ºC, and after 7:41 hr CST. Nonetheless, we detected many *S. indiana* after these flushing thresholds had been reached. *S. indiana* was significantly more likely to move and to flush when it was warmer, sunnier, or later in the day. By contrast, *S. lucens* was not significantly more likely to be active when it was warmer, sunnier or later in the day. Both species showed considerable fluctuation in abundance among years. For detecting *S. indiana*, sunny conditions at any time of day when it is < 16ºC appear ideal, followed by sunny and < 20ºC. When *S. indiana* individuals are active, it is still possible to find them if great caution is taken in approaching phlox flowers, especially by using binoculars to search phlox flowers. Effective diurnal surveys for *S. lucens* may occur in a broad range of weather and time of day.


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*Schinia indiana* (Smith) and *Schinia lucens* (Morrison) (Lepidoptera: Noctuidae) belong to the subfamily Heliothentinae, which includes species active during the day (like the two species studied here), the night, or both (Hardwick 1958, 1996; Covell, Jr. 1984; Matthews 1991). In general, the diurnal species of Heliothentinae usually become active in late morning to fly rapidly among blossoms for feeding and oviposition. While the species vary in degree of protective coloration, the camouflage afforded to individuals perched on flowers of the larval food plant (host) is remarkable in many species. Larvae feed on developing seed capsules or pods of the host, sometimes feeding on the flowers first. The number of generations per year appears determined by the length of the flowering period of the host(s): the moth species is multivoltine if and when the host(s) have a dependably long flowering season but univoltine if the primary period of bloom is relatively short. Univoltine species pass most of the year as pupae. Adults of some *Schinia* species come to ultraviolet light traps.

States with records of *S. indiana* occur primarily in central North America, from Arkansas and Texas to Minnesota, Wisconsin, and Michigan (Hardwick 1958, Balogh 1987). Forbes (1954) also listed North Carolina, but neither Hardwick (1958) nor Balogh (1987) located these specimens. Specimens averaged (± SD) 16.7 ± 1.3 mm in wingspan (N = 43 specimens) (Hardwick 1958). The

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host is downy phlox (*Phlox pilosa* L.) (hereafter called "phlox") (Polemoniaceae) (Hardwick 1958). Both Hardwick (1958) and Balogh (1987) emphasized the relatively inactive behavior of the species, with individuals resting most of the day on or among host blossoms. This species does not come to light traps (Les Ferge, Madison, WI, pers. comm.).

*Schinia indiana* is legally listed as Endangered in Wisconsin (Wisconsin Department of Natural Resources 2004) and is highly restricted to native sand savanna vegetation (Panzer et al. 1995). This moth is also listed as "Endangered" in Indiana and Michigan, and "Special Concern" in Minnesota, with a common name of phlox moth (Indiana Department of Natural Resources 2002, Michigan Department of Natural Resources 2002, Minnesota Department of Natural Resources 2007b).

The range of *S. lucens* is large, including localized records in Florida, North Carolina, Tennessee, and Michigan, and a wide distribution from central Illinois and southern Wisconsin northwestward to southern Manitoba and southwestward to central Texas (Metzler et al. 2005). Holland (1905) and Hardwick (1996) reported a westward distribution to the Rocky Mountains in Canada, interior Washington state, Arizona, montane southern California, and Baja California Norte, Mexico. Holland (1905) considered the species common in the central Great Plains, while Covell, Jr. (1984) considered it uncommon to rare in eastern North America. Adult wingspan is about 25-28 mm (Covell, Jr. 1984) and they can be found at ultraviolet light traps (The Lepidopterists' Society 1983, 1984). Wyatt (1938) and Hardwick (1996) specify *Amorpha californica* Nuttall and *A. canescens* Pursch (leadplant) (Fabaceae) as host plants. The host for *S. lucens* in the moth's prairie range is restricted to native grassland/prairie (Metzler et al. 2005).

Although *S. lucens* has no legal status for protection in Wisconsin (Wisconsin Department of Natural Resources 2004), it is highly restricted to native prairie vegetation (Panzer et al. 1995). Most provinces and states, including Wisconsin, have lost more than 99% of their tallgrass prairie in the past two centuries (Samson and Knopf 1994). This moth is legally listed as "Endangered" in Indiana and Michigan and was recently proposed as "Special Concern" in Minnesota, with a common name of leadplant moth or leadplant flower moth (Indiana Department of Natural Resources 2002, Michigan Department of Natural Resources 2002, Minnesota Department of Natural Resources 2007a).

Surveying and monitoring are necessary components of conservation programs, both to identify those species (of the ones effectively sampled) that do and do not require conservation action and to monitor the efficacy of conservation actions (Conrad et al. 2004, Groenendijk and van der Meulen 2004). Transect surveying can be effective in monitoring moth populations, especially of diurnally active species (Groenendijk and van der Meulen 2004, Young and Barbour 2004). However, the small size, high degree of camouflage, and potential activity level of these two *Schinia* species could affect their detectability in surveys.

In this paper, we report on daytime observations of *S. indiana* and *S. lucens* in Wisconsin (which is the northern part of their ranges) during 1994-2006, as well as during 1992 for *S. lucens*. We analyze variation in detection at three temporal scales: daily (weather and time of day variables), seasonal (date, host phenology), and annual (fluctuations in abundance, long-term trends). This information should improve the effectiveness of daytime surveys for these species.

## METHODS

We surveyed for *S. indiana* or *S. lucens* during general transect surveys for butterflies (Swengel and Swengel 1999). We conducted transect surveys along like routes within each site (similar to Pollard 1977) as described in Swengel

(1996, 1998). A new survey unit was designated whenever the habitat along the route varied by management or vegetation type. We also surveyed specifically for *S. indiana* by walking from host to host, choosing routes so as to search as many phlox plants as efficiently as possible, and searching especially host flowers and flower buds but also other parts of host plants. We did not follow a set route, but kept our surveying within the bounds of a single unit. For both butterfly and *S. indiana* unit surveys, we recorded time of day, temperature, wind speed, percent cloud cover, percent time sun was shining, route distance, and time spent surveying. Data from each unit were kept separate. Surveys occurred over a wide range of weather conditions and times of day. For nine of these *S. indiana* unit surveys ("informal" samplings in Swengel and Swengel 1999) with nine individuals recorded, we did not record survey distance and/or start/end times, due to time spent during the survey performing non-survey activities (orienteering, mapping, habitat description, etc.). These observations are included in analyses where possible.

Wing wear was evaluated on a categorical scale based on field descriptions and photographs: 1 = fresh, 2 = slightly faded, 3 = faded, 4 = very faded. During 1996-98 and 2001-06, for all unit surveys where we found *S. indiana*, we classified phlox flower phenology into five categories: mostly in bud (very few flowers), prepeak, peak (±0-2 days of peak), postpeak, well past peak (many wilted flowers). In 1997-98 and 2006, we consistently recorded phlox flower phenology in unit surveys throughout the *S. indiana* flight period whether *S. indiana* was recorded or not. The relative abundance of phlox plants (not flowers) for the unit and microsite of the moth's location was recorded using the following categories defined according to relative arithmetic ratios based on orders of magnitude: abundant (10,000), common (1000), uncommon (100), and sparse (10). For intermediate values, we used the average between the two values: e.g., common/abundant (5000), sparse/uncommon (50).

For *S. indiana*, we conducted 659 unit surveys (312 butterfly, 347 *S. indiana*) each year during 1994-2006 at 69 pine-oak barrens/savannas containing its host (264.6 km for all transects, 147.4 hr of total survey time) in central Wisconsin (Jackson, Juneau, Marquette, and northern Sauk Counties) and northwestern Wisconsin (Burnett County). Although the sites in central Wisconsin are at least 220 km from those in northwestern Wisconsin, they have a similar climate in the growing season (Curtis 1959). For *S. lucens*, we conducted 523 unit surveys (152.9 km, 68.8 hr) in 1992 and 1994-2006 at 12 prairies and a prairie garden planting containing its host in the southern half of Wisconsin (Crawford, Dane, Grant, Green, Iowa, and Sauk Counties) and at 3 pine-oak barrens/savannas (Burnett County) and a prairie (St. Croix County) in northwestern Wisconsin. The southern Wisconsin sites for *S. lucens* were a minimum of 240 km away from the northwestern ones.

*Schinia indiana* was consistently surveyed at four units in Jackson County, Wisconsin, each year during 1994-2006 (one unit was missed in 1994 and another in 1998), and at six units in Burnett County in eight years during 1994-2006 (two units were missed in 2005). We found *S. indiana* in at least three years (maximum 10) at each of these Jackson County units, and in at least one year (maximum six) at each of these Burnett County units. *S. lucens* was surveyed consistently at six sites in southern Wisconsin (Dane, Crawford, Green, Iowa Counties) during 1998-2006 (one site missing in 1998). We recorded *S. lucens* at each site during this period, and in more than one year during this period except at one site. Since we recorded only two *S. lucens* individuals in northwestern Wisconsin, we did not include this region in this analysis. We calculated an annual index of abundance as the mean of the peak observation rate (individuals/hour on a unit survey) at the monitoring units/sites each year. We also calculated an annual index of abundance for other units surveyed for *S. indiana* each year, including only those units where we had ever recorded *S. indiana* (sample of units varied in number and location among years). We did this only for eight years, excluding those years where only 0-2 other units were surveyed during *S. indiana* flight period. We did not perform this analysis for *S. lucens* because we did not survey enough other sites with the species to support analysis.

Survey characteristics (including date, time of day as Central Standard Time [CST], location, weather) and individuals observed were databased both by each unit survey and by individual moth. To make numbers comparable among unit surveys, we standardized them into rates of individuals observed per hour of survey time per unit survey. Analysis was done with ABstat 7.20 software (1994, Anderson-Bell Corp., Parker, Colorado), with statistical significance set at $P < 0.05$. Since significant results occurred much more frequently than would be expected due to Type I statistical errors (i.e., non-significant results receiving a spuriously significant $P$ value), we did not lower the $P$ value further, as many more Type II errors (i.e., biologically significant yet statistically non-significant results) would then be created than Type I errors eliminated. Scientific nomenclature for moths follows Hardwick (1996) and for vascular plants follows Kartesz (1994).

For each species, we tested for significant differences in whether individuals were active or not by weather conditions (temperature, percent sunshine, wind speed) and time of day (CST), with the Mann-Whitney U test. For *S. indiana*, we also tested for significant differences in whether individuals flushed or not, and were concealed (obscured by vegetation) or not (readily seen by a person standing near or over host) by the same variables. We did not do this for *S. lucens* because no individuals were concealed and only one individual flushed. Also only for *S. indiana*, we tested for a significant difference in host abundance in unit surveys during *S. indiana* flight period, between those units where we ever recorded *S. indiana* and those where we never did.

We used the Chi Square Goodness of Fit test to check for a significant difference in proportion of observed *S. indiana* individuals in each of the five phenological categories of phlox flowering vs. expected individuals based on survey time in each of these categories in units where we ever recorded *S. indiana* during this study.

All correlations were done with the Spearman rank correlation. We tested for correlation of wing wear rating vs. date (sequentially numbered). We tested for trend (correlation of year vs. annual indices of abundance). We also tested for significant correlation of annual indices of abundance between the long-term units and the other units (*S. indiana* only, by county).

## RESULTS

We recorded 264 *S. indiana* in 28 units in 15 sites in Jackson County and 25 units in 5 sites in Burnett County, from 23 May (2006) to 15 June (1994) (Fig. 1) based on 198.7 km of survey transects and 112.7 hr of survey. Both of those dates were from Jackson County. In Burnett County, we recorded them from 25 May (1999) to 13 June (2004). Within year, the longest flight period spans were 21 days in 1994 and 17 days in 2006, both in Jackson County, where we sampled on more dates per year. We found at least one individual in each category of phlox flower phenology, but the abundance of these individuals was significantly skewed to occurring in the prepeak and peak periods (Table 1). Phlox was significantly more abundant in surveys during *S. indiana* flight period in units where *S. indiana* had ever been recorded (mean rating 4213, N = 304 unit surveys) than in units where we never recorded the species (mean rating 2178, N = 101) ($P < 0.001$). Wing wear did not significantly correlate to date ($r = +0.090$, N = 201, $P > 0.10$).

We recorded 46 *S. lucens* in 9 sites in six counties (Crawford, Dane, Grant, Green, Iowa, Sauk) in southern Wisconsin, and 2 sites in two counties (Burnett,

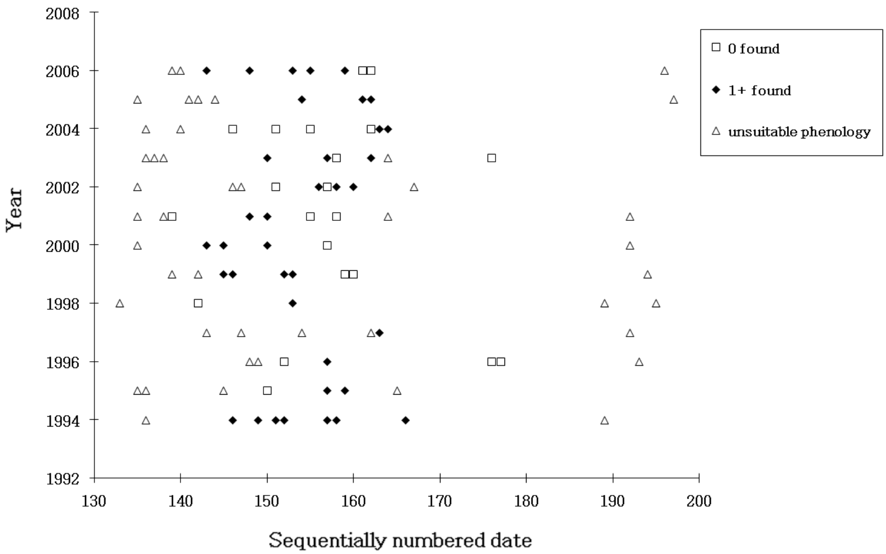


Figure 1. Survey dates in *Schinia indiana* site(s) in Wisconsin by year and phenology: "0 found" means we specifically searched for *S. indiana* and found none, "1+ found" means one or more *S. indiana* were recorded, and "unsuitable phenology" means we did not specifically search for *S. indiana* because it was either too early for phlox flowers or phlox flowering was mostly over. 130 = 10 May; 200 = 19 July. (In 2003, we did not attempt to find any *S. indiana* on 13 June, but we did search on 25 June in a site of slow phenology.) All dates are from Jackson County, WI, except the following are from Burnett County, WI: "0 found" = 142 (1998), 161 (2006), 162 (2006); "1+ found" = 146 (1994), 145 (1999), 146 (1999), 145 (2000), 160 (2002), 157 (2003), 164 (2004), 162 (2005), 148 (2006); and "unsuitable phenology" = 145 (1995), 143 (1997), 146 (2002), 137 (2003), 140 (2006).

Table 1. Distribution of *Schinia indiana* adults on downy phlox plants at five phenological stages of flowering. The number of observed individuals in 1997-98 and 2006 vs. the expected number of individuals based on the proportion of the survey effort in each phenological stage is significantly different (Chi Square = 17.6, $P = 0.0015$).

| | All individuals[1] | | Survey time[2] | | Observed[3] | | Expected[3] |
|---|---|---|---|---|---|---|---|
| **Phlox phenology** | **N** | **%** | **Hr** | **%** | **N** | **%** | **N** |
| Mostly in bud | 2 | 1.3 | 1.98 | 10.0 | 1 | 2.4 | 4.1 |
| Prepeak | 62 | 41.6 | 1.66 | 8.4 | 6 | 14.6 | 3.4 |
| Peak (±0-2 days) | 64 | 43.0 | 8.35 | 42.1 | 28 | 68.3 | 17.3 |
| Postpeak | 20 | 13.4 | 5.43 | 27.4 | 5 | 12.2 | 11.2 |
| Many wilted flowers | 1 | 0.7 | 2.41 | 12.1 | 1 | 2.4 | 5.0 |

[1] All *S. indiana* individuals were recorded during 1996-1998 and 2001-2006.

[2] Survey time in 1997-98 and 2006 was calculated from all units where we ever recorded *S. indiana* in this study.

[3] Observed individuals were recorded in 1997-98 and 2006; expected individuals were calculated based on proportion of survey time in each phenological category.

St. Croix) in northwestern Wisconsin, from 30 June (1998, Green County) to 29 July (2002, Burnett County) (Fig. 2) in 138.7 km and 62.7 hr of surveys there. Within year, the longest flight period spans statewide were 23 days (2002, starting in southern Wisconsin and ending in northwestern Wisconsin) and 15 days (2000, all in southern Wisconsin). While most visits to Burnett County in northwestern Wisconsin were classified as "casual search", we did routinely watch leadplant flowers for nectaring butterflies, and that is how the one very worn individual there was found. One date (9 July 1999) in northwestern Wisconsin was spent in St. Croix County. Wing wear significantly correlated to date ($r = +0.777$, N = 22, $P < 0.001$).

For both species, when one individual was found, it was useful to look on the same plant for another individual, even if obscured. For *S. indiana*, 80 individuals (30%) occurred in pairs on the same inflorescence/stem (with 18 individuals in mating pairs) and 4 (2%) together on one flower head (none mating). For *S. lucens*, 6 individuals (13%) occurred in pairs on the same flowering stem (none mating). As leadplant is much larger, with multiple branches, we also noted number of individuals per plant: 10 (22%) occurred in pairs on the same plant and in one instance, 3 (7%) occurred on the same plant.

One *S. indiana* flushed at 16ºC, but all other flushes occurred when it was ≥ 20ºC (Fig. 3). We recorded 67 individuals when it was ≤ 16ºC, and 142 individuals when it was ≤ 20ºC. The coldest temperature we recorded when finding *S. indiana* was 7ºC. No *S. indiana* flushed before 7:42 hr CST (Fig. 4); 52 individuals were recorded before this time, 33 at ≥ 16ºC, and 9 at ≥ 20ºC. We

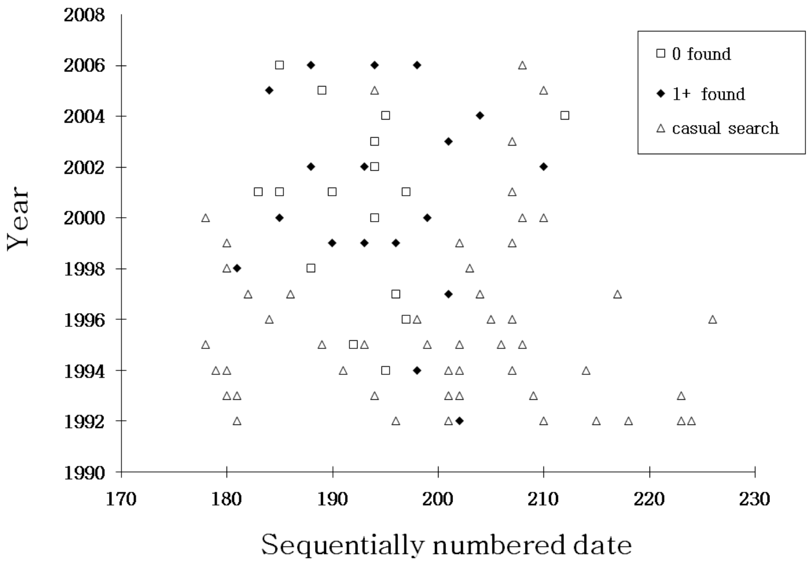


Figure 2. Survey dates in *Schinia lucens* site(s) in Wisconsin by year and phenology: "0 found" means we specifically searched for *S. lucens* and found none, "1+ found" means one or more *S. lucens* were recorded, and "casual search" means we did not specifically search for *S. lucens*, but noted it when we were looking at leadplant for nectaring butterflies (170 = 19 June, and 230 = 18 August). All sampling dates are from southern Wisconsin except the following are from northwestern Wisconsin: "0 found" = 212 (2004); "1+ found" = 190 (1999), 210 (2002); and "casual search" = 210 (1992), 209 (1993), 201 (1994), 202 (1995), 205 (1996), 204 (1997), 203 (1998), 202 (1999), 208 (2000), 207 (2001), 207 (2003), 210 (2005), 208 (2006).

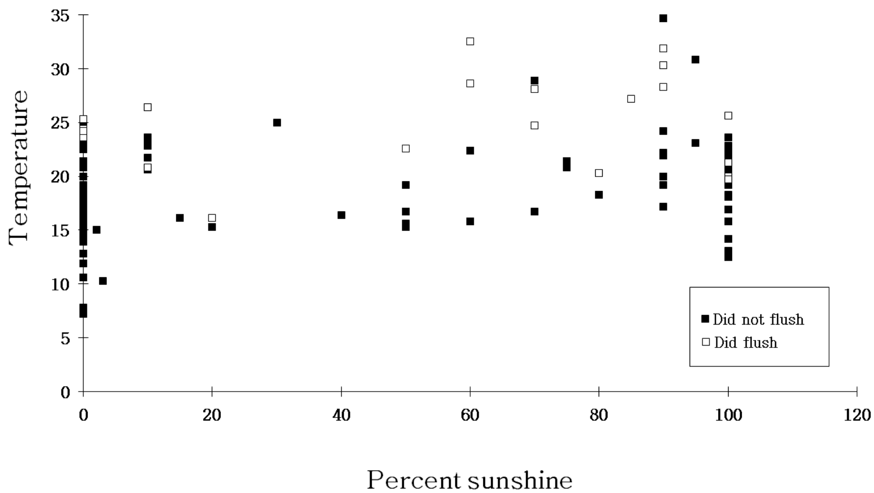


Figure 3. Occurrence of flushing by *Schinia indiana* adults in Wisconsin in relation to air temperature (°C) and percent sunshine.

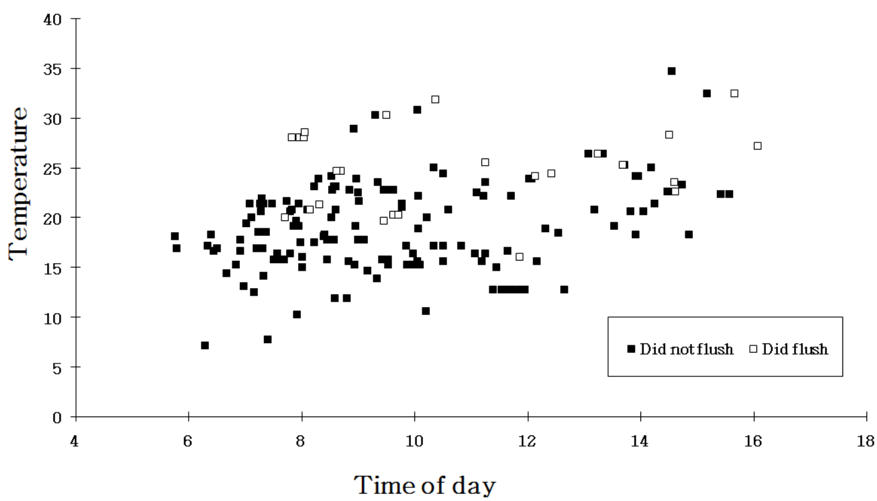


Figure 4. Occurrence of flushing by *Schinia indiana* adults in Wisconsin in relation to air temperature (°C) and time of day (CST, Central Standard Time).

recorded flushing throughout the rest of our survey day; the latest individual recorded was at 16:04 hr, and it flushed. Conversely, we recorded many *S. indiana* after these flushing thresholds had been reached (Figs. 3, 4): 167 did not flush when it was > 16ºC, 94 when it was ≥ 20ºC, 180 when it was later than 7:42 hr, and 85 when it was ≥ 20ºC and later than 7:42 hr.

*Schinia indiana* was significantly more likely to be active and to flush when it was warmer, sunnier, or later in the day (Table 2). Only 11 inactive individuals occurred when it was > 25ºC, up to 35ºC. They were also significantly more likely to move when it was windier but flushing did not significantly relate to wind (Table 2). Whether *S. indiana* was concealed or unconcealed did not significantly relate to temperature, sunshine, wind, or time of day (Table 2). However, we found only 8 concealed individuals when it was > 23ºC.

Whether *S. lucens* was active or not did not relate significantly to temperature, sunshine, wind, or time of day (Table 2). Active individuals occurred throughout most of the range of temperature (21-29ºC), sunshine (0-100%), and time of day (8:01-14:45 hr CST) as recorded for inactive individuals (19-31ºC, 0-100% sunshine, 7:32-16:20 hr). Only one individual flushed, under relatively warmer, sunnier conditions (28ºC, 85% sunshine) and after noon (12:16 hr). Concealment was not testable for *S. lucens* since they cannot conceal themselves within a leadplant inflorescence.

For *S. indiana*, we compared annual indices of abundance from long-term monitoring units (four in Jackson County, six in Burnett County) (Fig. 5) and other units (varying in number and location per year) in the same county where we had ever recorded the species. While the correlation was positive between long-term and non-long-term indices within county, this was far from significant in either county ($r$ = +0.595 in Jackson County, $r$ = +0.438 in Burnett County, N = 8 and $P$ > 0.10 for both). None of these indices had a significant long-term trend ($r$ = -0.049, N = 13 for Jackson County long-term units, -0.190, N = 8 for Jackson County other units, +0.048, N = 8 for Burnett County long-term units, +0.544, N = 9 for Burnett County other units).

At the monitoring sites in southern Wisconsin, *S. lucens* showed great variation in annual indices of abundance (Fig. 6), comparable to the variation in *S. indiana* indices (Fig. 5). *S. lucens* indices showed no trend ($r$ = 0.0, N = 9 years).

## DISCUSSION

While we only recorded 26 *S. indiana* individuals that flushed, this was no doubt an undercount, in that other individuals probably flushed before we saw or could identify them. Furthermore, once we had begun to identify the conditions under which activity and flushing became more likely (Swengel and Swengel 1999, which included surveys in other states), we attempted to prevent individuals from being disturbed and flushed (by approaching slowly, crouching over, or scanning flowers with binoculars first). This may explain why we found a few concealed individuals at higher temperatures than previously reported (Swengel and Swengel 1999: no concealed individuals at > 23ºC). Nonetheless, given that we recorded a total of 264 individuals overall, the numbers found after flushing thresholds were reached (Figs. 3, 4: 16ºC strictly, but 20ºC most of the time; 7:42 hr CST) were sufficient motivation for us to continue searching under those conditions. Percent sunshine did not show a threshold pattern (Figs. 3, 4), but in statistical testing, was greater for flushed than non-flushing individuals (Table 2). Temperature, sunshine, and time of day patterns (Table 2) appear directly related to *S. indiana* flushing behavior (as the individual becomes warmer, it becomes more active), but the (weaker) relationship of flushing to wind may be an indirect effect: either wind causes them to readjust position or wind makes it harder for us to search, so that we are more likely to

Table 2. Mean (± SE) time of day and weather variables measured at time of observation of *Schinia indiana* and *Schinia lucens* adults in Wisconsin by species and by whether the moth was active or not, flushed or not, and concealed or not.

| | **Mean** | **SE** | **Mean** | **SE** | ***P*** |
|---|---|---|---|---|---|
| *Schinia indiana* | | | | | |
| | Not active (N=228) | | Active (N=34) | | |
| Temperature (ºC) | 18.9 | 0.3 | 25.3 | 0.8 | <0.001 |
| Percent sunshine | 30.8 | 2.7 | 62.9 | 6.3 | <0.001 |
| Time of day[1] | 9.6 | 0.2 | 10.7 | 0.5 | <0.05 |
| Wind (km/hr) | 10.1 | 0.5 | 14.1 | 1.6 | <0.05 |
| | Not flushed (N=232) | | Flushed (N=26) | | |
| Temperature (ºC) | 19.0 | 0.3 | 24.9 | 0.8 | <0.001 |
| Percent sunshine | 31.8 | 2.7 | 56.7 | 7.4 | <0.01 |
| Time of day[1] | 9.6 | 0.2 | 10.9 | 0.5 | <0.05 |
| Wind (km/hr) | 10.1 | 0.5 | 14.0 | 2.0 | <0.1 |
| | Not concealed (N=205) | | Concealed (N=46) | | |
| Temperature (ºC) | 20.0 | 0.3 | 19.0 | 0.9 | <0.1 |
| Percent sunshine | 37.6 | 3.0 | 28.8 | 6.0 | >0.1 |
| Time of day[1] | 9.9 | 0.2 | 9.4 | 0.3 | >0.1 |
| Wind (km/hr) | 10.6 | 0.5 | 11.4 | 1.3 | >0.1 |
| *Schinia lucens*[2] | | | | | |
| | Not active (N=36) | | Active (N=9) | | |
| Temperature (ºC) | 23.8 | 0.5 | 25.0 | 0.9 | >0.1 |
| Percent sunshine | 60.8 | 5.6 | 66.1 | 10.4 | >0.1 |
| Time of day[1] | 10.0 | 0.4 | 10.9 | 0.8 | >0.1 |
| Wind (km/hr) | 10.0 | 0.9 | 11.2 | 1.6 | >0.1 |

[1]CST (Central Standard Time), converted to decimal (e.g., 9:15 hr became 9.25 and 9:30 hr became 9.5)
[2]Flushing and concealment were not analyzed for *S. lucens* because only one individual flushed and none were concealed.

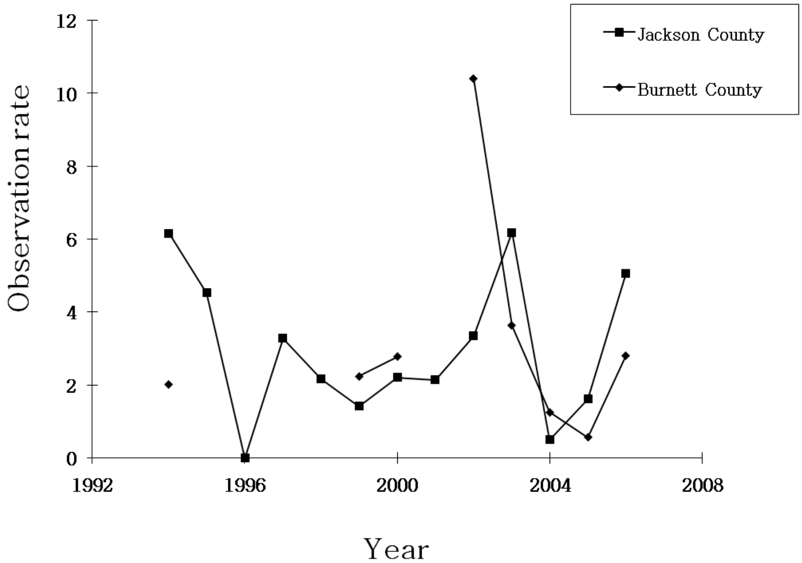


Figure 5. *Schinia indiana* average annual index of abundance (number of individuals observed per hour on the peak survey day for each unit, averaged for all units each year) at long-term monitoring units in Burnett and Jackson Counties, Wisconsin.

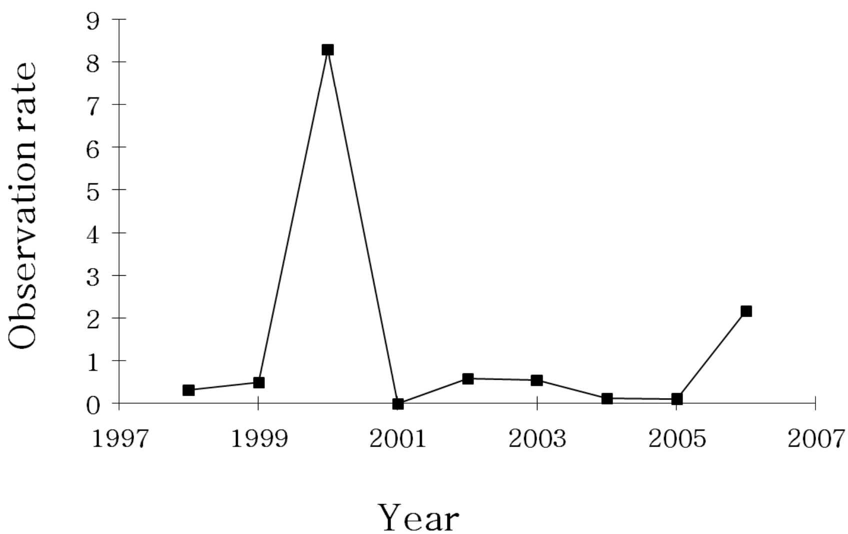


Figure 6. *Schinia lucens* average annual index of abundance (number of individuals observed per hour on the peak survey day for each unit, averaged for all units each year) at long-term monitoring units in southern Wisconsin.

disturb them. The results here slightly modify but remain consistent with our previously reported findings (Swengel and Swengel 1999: *S. indiana* individuals inactive at < 16°C and before 7:30 hr; all individuals active at > 25°C).

By contrast, activity by *S. lucens* showed no significant patterns relative to weather and time of day (Table 2), and we recorded active individuals under similar weather and time of day as inactive ones. In comparison to our previous report, we found a greater range of temperature and time of day for activity (Swengel and Swengel 1999: all *S. lucens* inactive at < 23°C and until 12:00 hr CST). But our previous finding of inactivity at high temperatures (29°C) is consistent with our results here. Furthermore, we detected flushing rarely, so this behavior is not an apparent impediment to detection. Summer conditions throughout a broad range of time of day are so warm that *S. lucens* can be active. They may flush under relatively warmer, sunnier, later conditions (and our relatively small sample may be inadequate to detect such tendencies), but they appear remarkably disinclined to flush. However, *S. lucens* is larger and easier to pick out on its host flowers. While *S. indiana* can hide within the inflorescence, this is not possible for *S. lucens* on leadplant inflorescences, which are also higher up above the ground. Thus, it is possible that our searching is less intrusive and disturbing for *S. lucens* than *S. indiana*.

We conclude that diurnal surveys for *S. lucens* may effectively occur in a broad range of weather and time of day. However, the large and predictable variation in *S. indiana* behavior relative to weather and time of day greatly affects efficacy of surveys for this species. Sunny conditions at any time of day when it is < 16°C are ideal, followed by sunny conditions at ≥ 16°C but < 20°C. In these cases, individuals may be in unconcealed positions so that they may bask, but are unlikely to flush (especially at < 16°C). Searching before 7:42 hr CST is also recommended regardless of sky condition, unless heavy rain occurred since the last time *S. indiana* could have been active. Heavy rain can knock over phlox plants, knock petals off phlox flowers, and, we infer, knock *S. indiana* off the plant (or cause the moth to drop off). If sufficiently warm and sunny conditions have not occurred since then, to allow *S. indiana* to reassume a perch on a phlox flower, then *S. indiana* individuals would be very hard to find in the drenched and knocked down vegetation or leaf litter. However, when rain is not hard enough to knock off petals and knock down plants, it can be a useful time to survey for phlox moths. Furthermore, it can be very effective to survey in cloudy conditions, especially at < 20°C, that follow warm and/or sunny conditions when *S. indiana* could have moved into unconcealed positions. The cloudy conditions would reduce activity by the moth, but it might retain the unconcealed position it adopted when active. When it is > 20°C, regardless of sky condition, *S. indiana* activity hampers detection, which is still possible if great caution is taken in approaching phlox flowers, especially by using binoculars to search phlox flowers. High wind also hampers searching phlox, which is easily moved by the wind.

For our long-term monitoring analyses (Figs. 5, 6), our sample of sites and counties is relatively small. Furthermore, relatively little information is available about the status and trend of these moths in Wisconsin from before our study, so that it is not possible to put our results into a longer-term context. It is inappropriate to use our monitoring results to make general conclusions about the status and trend of these species in Wisconsin. The lack of any significant long-term trends in our study may not be due to the actual lack of any trends for these species in the areas sampled. Rather, we may not have enough years and/or sites to obtain the statistical power necessary to yield significant results. Furthermore, should significant trends in fact be occurring, they may be due to climatic fluctuation rather than management and/or vegetation changes.

Our monitoring analyses (Figs. 5, 6) are most useful for demonstrating the large variability possible in monitoring datasets. This is an additional factor that must be taken into account in monitoring programs, and demonstrates the need to sample multiple sites in multiple years to characterize the occurrence of the species in an area and to learn conditions or techniques that improve survey efficiency.

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