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OBSERVATIONS ON *SCHINIA INDIANA* AND *SCHINIA LUCENS* IN THE MIDWESTERN UNITED STATES (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT.– *Schinia indiana* (Smith) and *S. lucens* (Morrison) are diurnal moths well camouflaged when perched on flowers of their host: *Phlox pilosa* L. (Polemoniaceae) and *Amorpha* (Fabaceae), respectively. We recorded 96 individuals of *S. indiana* in over 40 hours of daytime surveys, with five individuals in tallgrass prairies in three counties of Minnesota during 2-8 July in 1995-97 and 91 individuals in pine-oak barrens in two counties of Wisconsin from 26 May to 15 June in 1994-98. We recorded 57 individuals of *S. lucens* in over nine hours of daytime surveys in tallgrass prairies, with 33 in two counties of Minnesota during 5-10 July in 1995 and 1997, 18 in two counties of North Dakota during 3-10 July in 1995-97, and six in four counties of Wisconsin from 30 June to 21 July in four years during 1992-98. For *S. indiana*, all individuals were inactive below 16°C, but below 23° for *S. lucens*, while all *S. indiana* individuals were active above 25°, but some *S. lucens* individuals were still inactive at 29°. When warmer than 23°, no perches of *S. indiana* were obscured. Before about 0730h CST, no individuals of *S. indiana* were active but afterward some were, compared to around 1200h for *S. lucens*. All individuals of both species were associated with their host plant, with multiple individuals nonrandomly clustered on the same plant. Most individuals of *S. indiana* (99%) and *S. lucens* (87%) were on a host flower part as their first or only perch, with the remainder on a host leaf. In four sampling areas in central Wisconsin surveyed during the flight period of *S. indiana* in at least four of the five study years, relative abundance on the peak survey per area per year varied greatly among years.

KEY WORDS: Arizona, Asteraceae, Baja California, biology, California, Canada, Colorado, diurnal moths, Fabaceae, Florida, *Hesperia*, Hesperiidae, Homoptera, hostplants, Illinois, *Incisalia*, Iowa, *Luperina*, *Lycaeides*, Lycaenidae, Mexico, Minnesota, Nearctic, Nebraska, North Carolina, North Dakota, Nymphalidae, *Oarisma*, Onagraceae, Ontario, pine-oak barrens, Polemoniaceae, *Schinia*, seasonality, South Dakota, *Speyeria*, surveys, tallgrass prairie, Texas, Wisconsin, Wyoming, Zygaenidae.

The phlox flower moth, *Schinia indiana* (Smith, 1908), and leadplant flower moth, *Schinia lucens* (Morrison, 1875) (Lepidoptera: Noctuidae), belong to the subfamily Heliothinae (also called Heliothidinae and Heliothentinae), which includes species active during the day, the night, or both. The diurnal species usually become active in late morning to fly very 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 is remarkable in many species. The most camouflaged species seem to have the most sedentary habits. Larvae feed on developing seed capsules or pods of the larval host plant, sometimes feeding on the flowers first. Mature larvae pupate at or below the soil surface; many species are known to burrow into the ground to pupate but to an unknown depth in nature, presumed to be at least several inches. The flight period 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 is 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. (Hardwick, 1958, 1996; Covell, 1984; Matthews, 1991).

Holland (1903) reported *S. lucens* to be common in Nebraska and westward to Colorado and Wyoming but Covell (1984), listing the range as North Carolina to Florida west to Illinois, South Dakota, and Texas, considered it uncommon to rare. Hardwick (1996) reported a distribution in Canada from northwestern Ontario westward through the Prairie Provinces to the Rocky Mountains; in the USA from the Midwest westward to interior Washington and montane southern California, southward to Texas and southeastern Arizona; and in Mexico, in Baja California Norte. The wingspan is about 25-28mm and the host is leadplant (*Amorpha* L.) (Fabaceae) (Covell, 1984). Hardwick (1996) specifies *A. californica* Nuttall and *A. canescens* Pursch from labels of reared specimens. Records of *S. lucens* in the midwestern USA during 1979-97 come from Illinois (TLS, 1980-82, 1988-92), Iowa (TLS, 1989), Michigan (TLS, 1989, 1992), Minnesota (TLS, 1996), Nebraska (TLS, 1992), North Dakota (TLS, 1996), and Wisconsin (TLS, 1980, 1983-85, 1988-89, 1991-97). The species can be found at ultraviolet light traps (TLS, 1983-84).

Balogh (1987) reported specimens of *S. indiana* from Arkansas, Michigan, Minnesota, Nebraska, Texas, and Wisconsin; Hardwick (1958) reported specimens from northwestern Indiana and the nearby Chicago, Illinois area, which averaged 16.7 ±1.3mm in wingspan (N=43 specimens). Forbes (1954) also listed North Carolina in the species' range, but neither Hardwick (1958) nor Balogh (1987) located these specimens. Records for *S. indiana* in the midwestern USA during 1979-97 come from only three states: Michigan (TLS, 1986, 1988-91), Minnesota (TLS, 1996, 1998), and Wisconsin (TLS, 1988, 1990, 1992-98). The host is downy phlox (*Phlox pilosa* L.) (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, pers. comm.) and is listed as endangered in Wisconsin (BER, 1997)

In this paper, we report on daytime observations of both species in northern midwestern states during 1992-98. We provide information useful for improving the effectiveness of daytime surveys for these species, including flight period dates, effects of weather and time of day on location and activity, variation in numbers among years, and habitat associations.

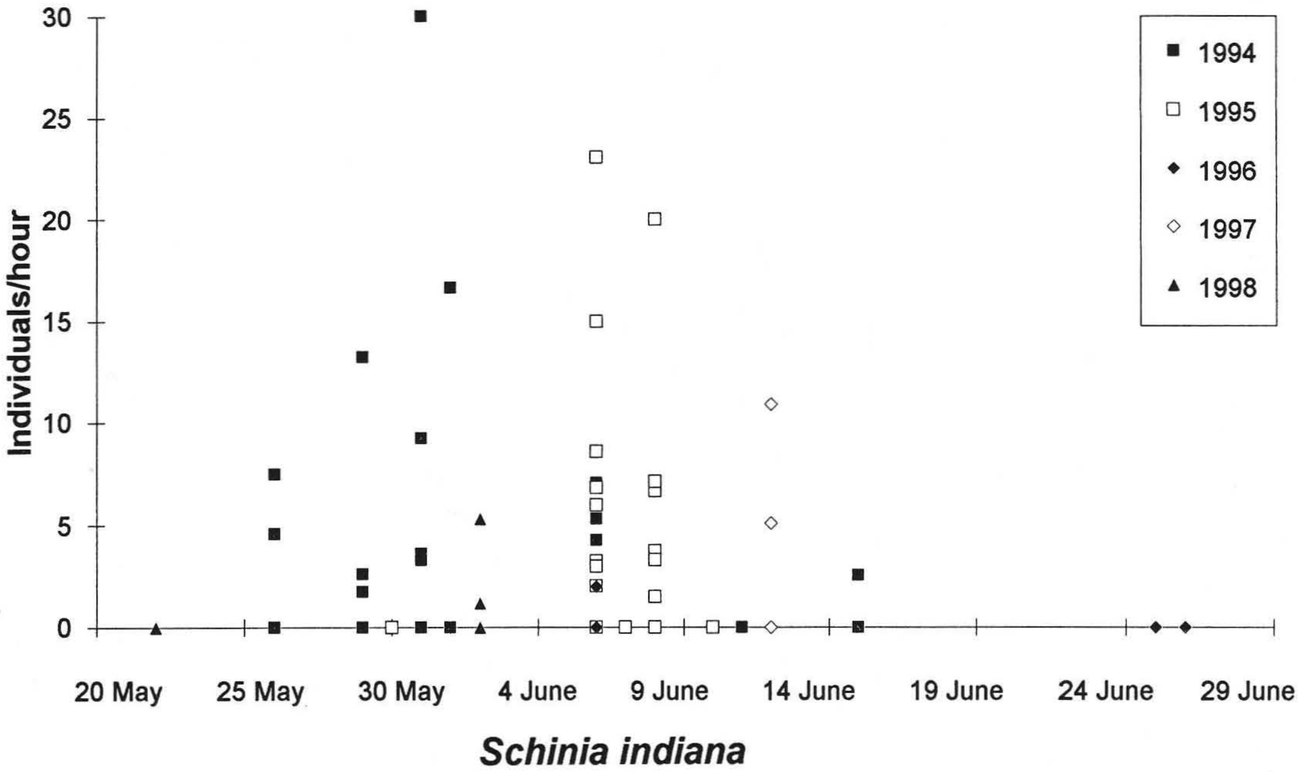

Fig. 1. Observation rates of *Schinia indiana* individuals/hour per survey unit (sampling area) by date for each year 1994-98.

METHODS

We surveyed informally for *S. indiana* and/or *S. lucens* incidental to site exploration and the conduct of formal transect surveys for butterflies (Swengel, 1996, 1998). An informal sampling is included in this paper only if we were making some particular effort to notice a *Schinia*, whether we found any or not. We also surveyed formally and specifically for these *Schinia* species by walking from larval host to host, searching especially host flowers and flower buds but also other host plant parts as well. For most surveys, we recorded temperature and estimated wind speed, percent time the sun was shining, percent cloud cover, and start and end times. For *S. indiana*, we conducted 175 samplings (77 informal, 98 formal) in each of five years (1994-98) at 77 sites: one tallgrass prairie in northern Iowa (Emmet County), seven tallgrass prairies in western Minnesota (Becker, Douglas, Lyon, Pipestone, and Pope Counties), and 69 pine-oak barrens in central and northwestern Wisconsin (Burnett, Jackson, Marquette, and Sauk Counties). For *S. lucens*, we conducted 59 samplings (47 informal, 12 formal) in six years (1992, 1994-98) at 13 sites: four tallgrass prairies in Minnesota (Clay and Norman Counties), four prairies in North Dakota (Ransom and Richland Counties), and 3 tallgrass prairies, 1 prairie garden planting, and 1 pine-oak barren in Wisconsin (Dane/Iowa, Grant, Green, and Sauk Counties). Sites were selected for their convenience (we were already in or en route through the area because of butterfly research) and potential to support the species because of habitat type and presence of the host plant.

Survey characteristics (date, time, location, weather, etc.) and results were databased both by each sampling and by individual moth with ABstat 7.20 software (1994, Anderson-Bell, Parker, Colorado). Surveys varied in amount of distance and time spent searching. It is difficult to estimate distance covered because of the erratic routes used to move from host to host, but it is easy to measure precisely the amount of time spent searching. Thus, to make numbers comparable among surveys, we standardized them into observation rates of individuals observed per hour of survey time, per sampling. Wing wear was evaluated on a four-point categorical scale based on field descriptions and photographs: 1 = fresh, 2 = slightly faded or worn, 3 = somewhat faded or worn, 4 = very faded or worn. We recorded the relative abundance of *P. pilosa* plants (not flowers) for the unit and/or microsite of the moth's location using these categories defined according to relative arithmetic ratios based on orders of magnitude: abundant (10,000), common (1000), uncommon (100), and sparse (10). Intermediate values were possible: e.g., common/abundant (5000), sparse/uncommon (50). Scientific nomenclature for Lepidoptera follows Hodges *et al.* (1983); English names follow Covell (1984) and NABA (1995).

S. indiana was consistently surveyed at four sampling areas in Jackson County, Wisconsin over consecutive years (one site in 1994-97, another in 1995-98, and two sampling areas of South Brockway west of the road during 1994-98). Annual variation in detectability was analyzed by comparing the peak survey totals (individuals/hour per sampling) among these areas per year. Surveys at these sites during the flight period occurred on a number of days in 1994-95, so that a peak was readily identifiable. Since surveys in 1996-98 occurred on fewer days, peak flight was less precisely identified, but all analyzed surveys were during appropriate host phenology, based on 1994-95 observations. *S. lucens* was not surveyed consistently at the same sites in consecutive years.

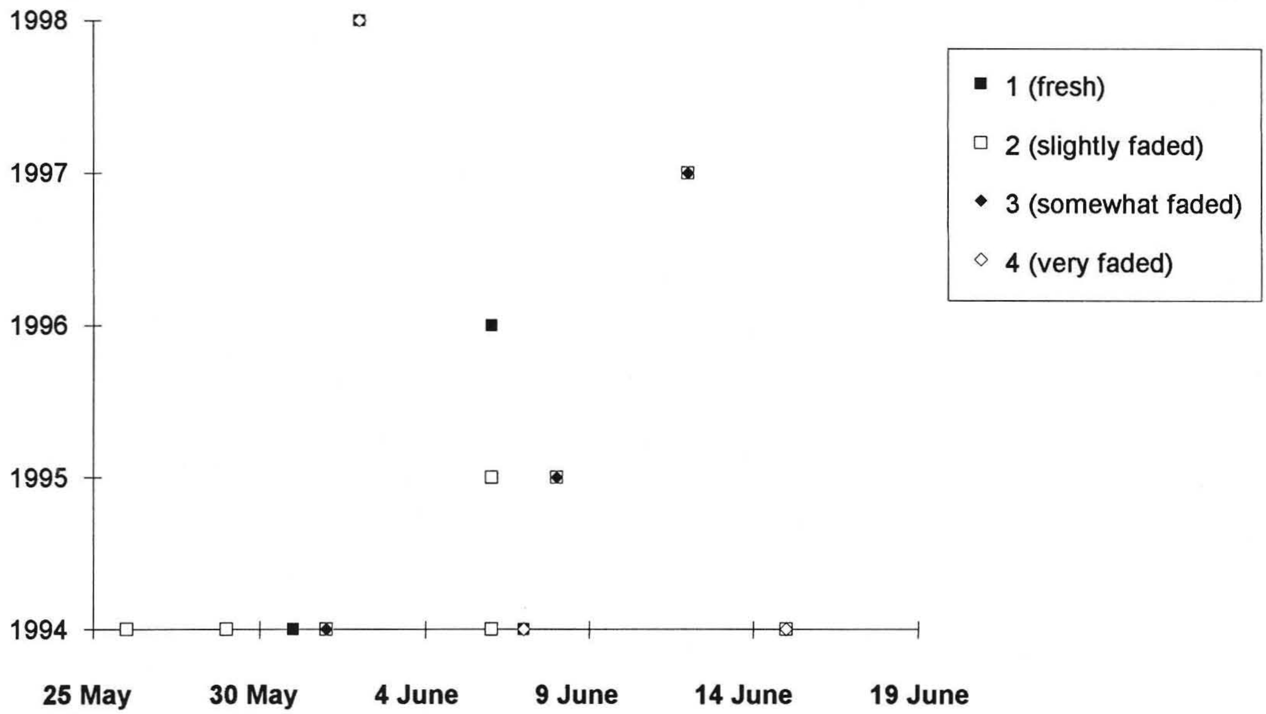

Fig. 2. Wing wear of *Schinia indiana* individuals in each year (N=55 individuals). Fresh individuals not depicted in the figure occurred on 26 and 29 May 1994, 6 June 1994, 6 June 1995, and 12 June 1997.

RESULTS

Localities and Flight Periods

We recorded 96 individuals of *S. indiana*: 17 in 77 informal samplings totalling 18.0 hr of effort and 79 in 98 formal samplings exceeding 22.7 hr (on 80 timed samplings). The five records in Minnesota were at Prairie Coteau, Pipestone County (N=2); Prairie Marshes Wildlife Area, Lyon County (N=2); and Staffanson Prairie, Douglas County (N=1); the 91 records in Wisconsin at one area at Crex Meadows Wildlife Area (N=1) and one area in Burnett County Forest (N=1), which were about 1.6 km apart, and at 19 sites in 12 different sections (square mile areas) of Jackson County within an area of 8 x 9 miles (13 x 15 km) in Black River State Forest and Jackson County Forest (N=89).

We recorded 57 individuals of *S. lucens*: 16 in 47 informal samplings exceeding 6.85 hr (on 42 timed samplings) and 41 in 12 formal samplings totalling 2.5 hr. The 33 records in Minnesota were at Bicentennial Prairie (N=2), the nearby hayed prairie west of the gravel pit (N=5), and Bluestem Prairie (N=25), all in Clay County, and Frenchman's Bluff Prairie, Norman County (N=1); the 18 records in North Dakota at 7 areas, each in a different section within an area of 14 miles x 10 miles (23 x 16 km), in and near Sheyenne National Grassland in Ransom and Richland Counties; the 6 records in Wisconsin at Dewey Heights (N=2), Muralt Bluff (N=2), and Thomson Prairies (N=1), in Grant, Green, and Dane/Iowa Counties, respectively, and in a prairie garden planting around a building at the International Crane Foundation, rural Sauk County (N=1). Two different background colors on fresh individuals were apparent (Plate 1, Fig. 1).

Our observations of *S. indiana* in Minnesota occurred during 2-8 July 1995-97, with one individual rated as slightly faded (code=2) on 2 July 1995 and one rated as fresh (code=1) on 8 July 1997. In Wisconsin they spanned 26 May to 15 June in 1994-98, out of a possible range of survey dates from 22 May to 26 June, with some variation in phenology among years (Fig. 1). Peak densities (individuals/hour per survey) in 1995 and 1996 occurred on 6 June, but on that date in 1994, the flight was after and lower than peak. The 1994 peak occurred on 30 May, but none were found in known sites on that date in 1995 and none on 1 June in 1996. Searches in 1997 were delayed until 12 June because of the slowness of plant development. In Wisconsin, fresh individuals (code=1) occurred from 26 May to 12 June (i.e., most of the flight period) but the greater the wear, the later in the flight (relative to host phenology) the observation tended to be (Fig. 2).

Our observations of *S. lucens* in Minnesota occurred during 5-10 July in 1995 and 1997; in North Dakota during 3-10 July in 1995-97, and in Wisconsin on 21 July 1992, 17 July 1994, 20 July 1997, and 30 June 1998. Only 12 individuals were rated for wing wear, with wear increasing the later the date: the eight individuals rated on 3-4 July 1995 in North Dakota were fresh (code=1), the one rated on 5 July 1995 in Minnesota was fresh, the one rated on 6 July 1995 in Minnesota was somewhat faded (code=3), and two observed on 21 July 1992 in Wisconsin were slightly (code=2) and somewhat (code=3) faded.

Host phenology at the time individuals of *S. lucens* were observed varied from early flowering (some flowers open, many still in bud) for a few individuals to near peak (most flowers open, but some still in bud) for most individuals. We did not conduct searches for *S. lucens* at later flowering phenologies. For our records of *S. indiana*, the host was usually near peak flowering, with some buds still unopened but few or no blooms wilted. We conducted a few surveys when the host was mostly in bud, with just a few flowers open, on 30 May 1995 and 1 June 1996, but found no individuals in known sites. On 25-26 June 1996, we conducted searches later in the flowering phenology, with some blooms wilted but the majority of flowers still in fine condition. We found no individuals, but this appeared to be a low year for numbers (see "Variation in numbers among years", below). At about that same phenology in 1994, we found three individuals on 15 June, but that year had higher numbers and a warmer spring season. Perhaps the time span may have been shorter between the beginning of the flight period and that flower phenology on 15 June 1994 than between the beginning of the flight period (sometime between 1 and 6 June 1996) and the same flower phenology on 25-26 June 1996. Based on these observations of flight period relative to flowering phenology, we presume the flight had already begun on 22 May 1998 in Burnett County, even though we found none in our searches, including at known sites. The host was slightly past peak, with most flowers still in fine condition, but a few wilted.

Although the Burnett County study area is over 225 km northwest of the Jackson County study area, these two areas in Wisconsin seem to have similar phenological development. In 1998, Burnett County actually appeared ahead of Jackson County, at least in *P. pilosa* phenology, perhaps because it was generally less cloudy in Burnett County during April and May (pers. obs. of televised weather maps). According to Curtis (1959), the two counties are similarly situated in relation to the "tension zone" between vegetative communities of southern Wisconsin and northern Wisconsin. This tension zone relates to growing season climate (Curtis, 1959).

Weather, Time of Day, and Behavior

Both presence and absence records for each species fell throughout the range of temperatures, degree of sunniness, and times of day for the surveys. However, whether individuals of both species were active (moving, readjusting in response to wind, feeding, flushing, flying) or not did relate to temperature and time of day. All individuals were inactive below 16°C for *S. indiana* but below 23° for *S. lucens*, while all *S. indiana* individuals were active above 25°, but some *S. lucens* individuals were still inactive even at 29° (Fig. 3). The *S. indiana* individuals active at the lowest temperature in Fig. 3a included one that flew away after exposure to four minutes of sunshine following six minutes in the shade and one that moved seemingly in response to a breeze and then resumed immobile perching (never flushing). All other active *S. indiana* individuals flushed (or were flying upon first observation), except one individual at the warmest temperature in Fig. 3a, which reacted to wind by readjusting its perch but did not flush in response to us or nectaring by an Indian skipper (*Hesperia sassacus* Harrison) (Hesperiidae). It remained on the same perch from 1510-1633h CST, with little change in temperature. These *Schinia* species didn't seem to show any clear patterns in relation to percent sunshine (Fig. 3).

Each species had a threshold in time of day before which no individuals were active and after which both active and inactive individuals were observed (Fig. 4). *S. indiana* had the lower threshold (around 0730h CST), compared to around 1200h CST for *S. lucens*. Surveys did not occur late enough in the day to define the threshold for resuming complete inactivity, which can be inferred to occur given the complete inactivity observed for both species at the beginning of the day.

For *S. indiana* individuals, we evaluated whether the perch upon first observation was unhidden to a standing person, or hidden such that a person would need to be lower and closer, possibly manipulating the plant, to be able to locate the individual (Plate 1, Fig. 3). We did not evaluate *S. lucens* perches, as we did not search the interiors of the host and individuals on host inflorescences were typically unhidden. Whether perches of *S. indiana* individuals were hidden or not showed a threshold temperature of 23°C, below which either situation was possible (i.e., they roosted both unhidden and hidden) but above which no individuals were found hidden (Fig. 5).

Most resightings of the same individual of *S. indiana* later in the day consisted of individuals becoming less hidden, better positioned for more efficient basking, and/or more active and prone to flush, as the morning progressed, the temperature warmed, and/or the sunniness increased. In one case, a resighting implied activity at a cooler temperature than detected by direct observation. On 8 June 1995, an individual was found at 1157h CST (13°C, 0% sun, 100% clouds) on the dorsal surface of a host flower. With similar weather inbetween, it was found again at 1248h CST on the same plant but the ventral surface of a petal.

Most individuals of both species were first observed perched: 87 *S. indiana* (91%), 55 *S. lucens* (96%). Of the remaining *S. indiana*, one was flying and nectaring on the host, two flushed, and six were mating. One mating pair each occurred in Jackson County on 1 June 1994 (100% sun, 16°C, 0741h CST), 6 June 1995 (0% sun, 25°C, 1411h CST), and 6 June 1996 (0% sun, 22°C, about 1530h CST). No mating pair showed a response to our activities, including photography of each pair. Of the two remaining *S. lucens*, both were nectaring on *A. canescens*. Our field notes were adequate to evaluate the response to our presence by 91 individuals of *S. indiana* and 54 individuals of *S. lucens*. Most appeared unresponsive – 82 *S. indiana* (90%), 50 *S. lucens* (93%) – while 2 *S. lucens* moved (without flying) and 9 *S. indiana* and 2 *S. lucens* flushed. Flight by *S. indiana* was fluttery and rapid and difficult to track. The few individuals we were able to follow at all flew horizontally about 1 m above the ground over the vegetation. Flight by *S. lucens* was similar.

All individuals of both species were associated with their host (perched, nectaring, or landing on it, or flushing from it). All individuals but one (99%) of *S. indiana* were observed on a *P. pilosa* flower part for their first or only perch: four individuals on flower bud(s), one on a pedicel (stalk of a single flower in an inflorescence), six on the corolla "tube" (united basal portion of the petals), 63 on the dorsal surface of petal(s) (one of these somewhat hidden by the petal of another flower), and 20 on the ventral surface of petal(s), for a total of 94. One individual, after flushing from a *P. pilosa* flower, landed briefly on two wild lupine flowers (*Lupinus perennis* L.) (Fabaceae) and one *P. pilosa* flower, before disappearing in flight. Only one *S. indiana* individual (1%) was on another host plant part, the dorsal surface of a leaf (Plate 1, Fig. 4). Of 29 *S. indiana* individuals (including three in Minnesota) for which we described the color of the flower they were perched on, only one flower was "semifaded" and two "average" in pink color, with the remainder "beautiful" [i.e., fresh and pink], "(very) bright [pink]", "very pink", or "incredibly deep pink", including the perches of very faded individuals (Plate 1, Fig. 2). Relatively fewer, but still most, individuals (87%) of *S. lucens* with data available on their first or only perch (52 individuals) were on a flower part of *A. canescens*: one at the interface between flower buds and open flowers, seven on flower buds, 20 on open flowers, and 17 on the bud and/or flower, for a total of 45. Seven *S. lucens* individuals (13%) were on a leaf of *A. canescens* (Plate 1, Fig. 5).

Of 94 *S. indiana* individuals with data available on number of individuals per stem, 32 (34%) occurred in pairs on the same stem and 4 (4%) together on one flower head (Pl. 1, Fig. 6). The closest nonmating individuals were right next to each: one pair was aligned

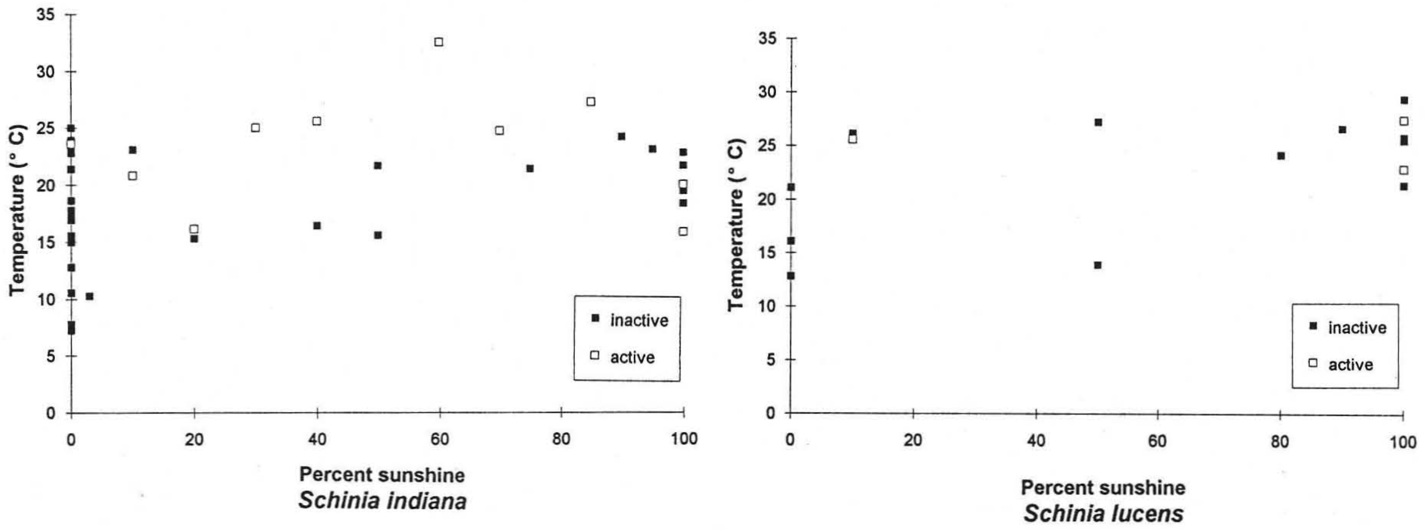

Fig. 3. Temperature (°C) and percent sunshine during surveys for individuals of (a) *Schinia indiana* (80 inactive individuals, 12 active) and (b) *S. lucens* (3 active individuals, 42 inactive).

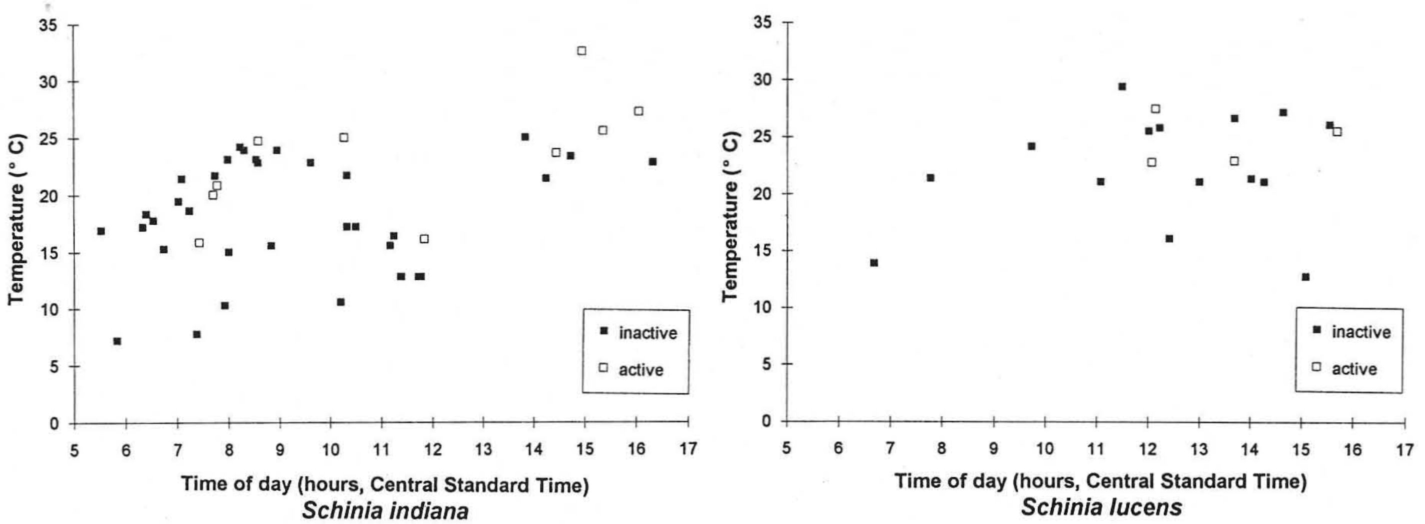

Fig. 4. Temperature (°C) and time of day during surveys for individuals of (a) *Schinia indiana* (80 inactive individuals, 12 active) and (b) *S. lucens* (48 inactive individuals, 5 active).

anterior of one at posterior of other and two other individuals were on either side (dorsal and ventral surfaces) of the same flower on adjacent petals, with their faces about 3 mm apart with a petal surface between them. *S. lucens* individuals seemed a bit more solitary. While 19 of 56 (34%) individuals were in pairs on the same plant, their host is much larger and multiply branched per stem, compared to the host of *S. indiana*. Only 6 (11%) individuals of *S. lucens* were found in pairs on the same stem.

Variation in Numbers Among Years

In the four sampling areas in Jackson County, Wisconsin surveyed during the flight period of *S. indiana* in at least four of the five study years, relative abundance on the peak survey per area per year varied greatly among years (Fig. 6). No individuals were found in these areas in 1996, although two individuals were found elsewhere in the same county that year (Fig. 1). In 1994 and 1997, we found *S. indiana* on the first day attempted, within 1 minute and 1 hour, respectively, of initiating searches. In 1995 and 1996, we found our first individual on the second day attempted (within 5.5 and 1.25 hours, respectively), but the first day was very early in *P. pilosa* flowering phenology (accounting for 5.25 and 0.1 hours of effort, respectively). In 1998, we found our first individual on the second day attempted (within 4.7 hours), and the flowering phenology was well along on the first day (accounting for 4.15 hours, all casual surveying except for formal surveying in the first 0.5 hour). Counting only days of appropriate host flowering phenology, we found an individual on the first day attempted except on the second day in 1998, and within 1 minute to less than 5 hours of searching effort.

Site Characteristics

In Minnesota, *S. indiana* occurred in uncanopied, dry-mesic to dry, undegraded prairie (Plate 2, Fig. 7). All sites were preserves in fire management, with individuals found in the second, third, and seventh growing seasons postburn (options in those sites on those dates were first, second, third, and seventh years postfire). We have also recorded regal fritillary (*Speyeria idalia* (Drury)), Poweshiek skipperling (*Oarisma poweshiek* Parker), and Dakota skipper (*Hesperia dacotae* Skinner) (Nymphalidae, Hesperiidae, and Hesperiidae, res-

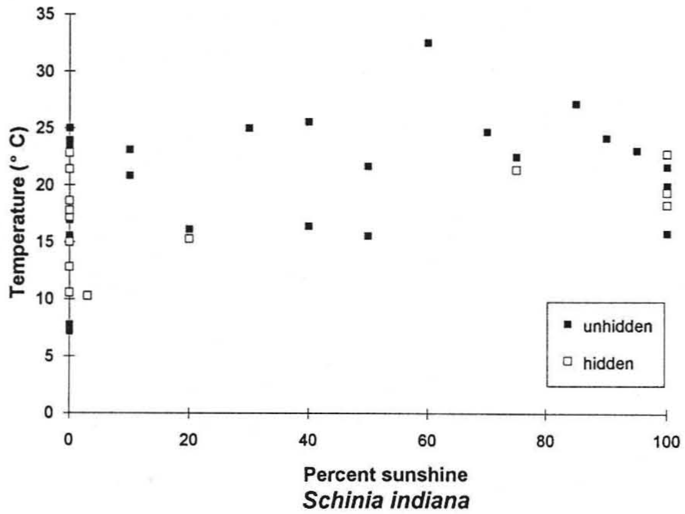

Fig. 5. Temperature (°C) and percent sunshine during surveys for individuals of *Schinia indiana* (68 unhidden individuals, 22 hidden).

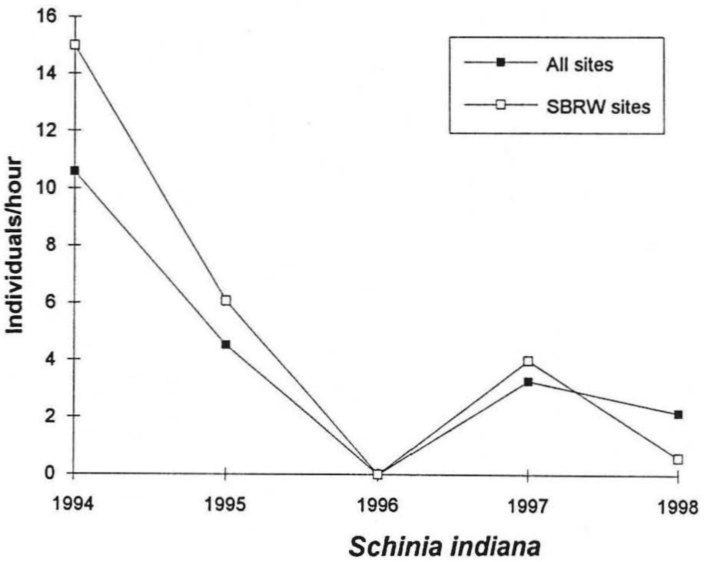

Fig. 6. Peak survey (individuals/hour) per survey site, averaged for each year for sites surveyed at least four out of the five years during 1994-98. "All sites" consists of five sites, with four surveyed in 1994 and 1998 (the one missing is different in 1994 and 1998) and all five sites surveyed each year in 1995-97. "SBRW" consists of two different subsites (sampling areas) of the South Brockway site (west of road), both surveyed each year during 1994-98.

pectively) at all these Minnesota sites. In Wisconsin, *S. indiana* occurred in pine-oak barrens (with sandy, very dry soil), with two individuals in rather degraded roadsides, 28 in somewhat degraded vegetation, and the remaining 61 in undegraded vegetation (Plate 2, Fig. 8). Two individuals were in annually mowed roadside powerline rights-of-way, two in sites with unintensive forest management (one naturally regenerating after timber cutting, the other a young pine plantation with the area between rows left intact during planting), 56 in areas burned by wildfire 17-21 years ago and otherwise left unmanaged, 30 in wildfire areas burned 5, 8, and 17-19 years ago with additional management since (trail/trackside, timber planting, roadside mowing), and one in an area managed with both fire and mowing (first growing season since mowing, sixth since burning). Most Wisconsin sites also supported Karner blue (*Lycaeides melissa samuelis* Nabokov), and some also supported cobweb skipper (*Hesperia metea* Scudder) and frosted elfin (*Incisalia irus* [Godart]) (Lycaenidae, Hesperiidae, and Lycaenidae, respectively).

S. indiana was recorded in units (sampling areas) with a wide range of *P. pilosa* abundance, from sparse/uncommon to common (for 45 moth individuals with this information available). For two of the three individuals recorded in units containing sparse/uncommon host, we also made an assessment of the microsite host abundance, and it was considered uncommon/common. All three individuals occurred in Jackson County, Wisconsin, in the context of numerous sites in the neighboring landscape that contained host. Likewise, we recorded *S. indiana* in microsites (local areas within a unit) containing a wide range of host abundance, from sparse to common/abundant (40 individuals). Of 28 individuals where both unit and microsite host abundance was assessed, most occurred in places with locally more abundant host than in the unit as a whole (15 individuals) or in microsites with host abundance comparable to that of the unit as a whole (10 individuals). Only three individuals occurred in a microsite with host sparser than that of the unit as a whole. *P. pilosa* often had a clumped distribution within sites.

In Minnesota, *S. lucens* occurred in undegraded, mesic or dry prairie (Plate 2, Fig. 9), with five individuals in a biennially late-season hayed site (four individuals in the first growing season after haying, one in the second) and 28 in fire-managed sites: 24 individuals in the first growing season after burning (23 within 5-50 meters of prairie not burned that year), one in the second, and three in the third (options in those sites on those dates were first, second, third, fourth, and fifth years postfire). In North Dakota, *S. lucens* occurred in somewhat degraded to undegraded prairie of dry-mesic, dry, and sandy dry soil types, all grazed by rangeland cattle except for one in an annually hayed site near grazed prairie. In Wisconsin, *S. lucens* occurred in somewhat degraded to undegraded dry fire-managed prairie in the third (three individuals), seventh (one individual), and eighth (one individual) growing seasons postburn, out of a possible second through tenth seasons postfire surveyed. One individual was on a host in a prairie garden planted as landscaping around a rural building near both prairie plantings on former farm fields and remnant original but somewhat degraded prairie, both supporting host.

DISCUSSION

Localities and Flight Periods

The first observation of *S. indiana* at Prairie Coteau in Pipestone County, Minnesota was by Dennis Schlicht and others in 1995 (D. Schlicht, pers. comm.). We did not find *S. indiana* at Anderson Prairie in Emmet County, Iowa, but others during the time period of this study did (D. Schlicht, pers. comm.). Those observations and ours contribute the first records in Minnesota in nearly two decades, plus the first known observation in Iowa (cf. Balogh, 1987).

The flight period in this study from 26 May to 15 June for *S. indiana* in Wisconsin, with presumed flight on 22 May and even earlier in 1998, is similar to others' reports during 1979-97 of 18 May to 11 June in Michigan (TLS, 1986, 1988-1991) and 23 May to 8 June in Wisconsin (TLS, 1988, 1990, 1992-94, 1998). The first two specimens from the type locality in northwestern Indiana date from 30 May and 13 June 1908 (Hardwick, 1958); Hardwick reported a maximum span from 27 May to 17 June for specimens from the

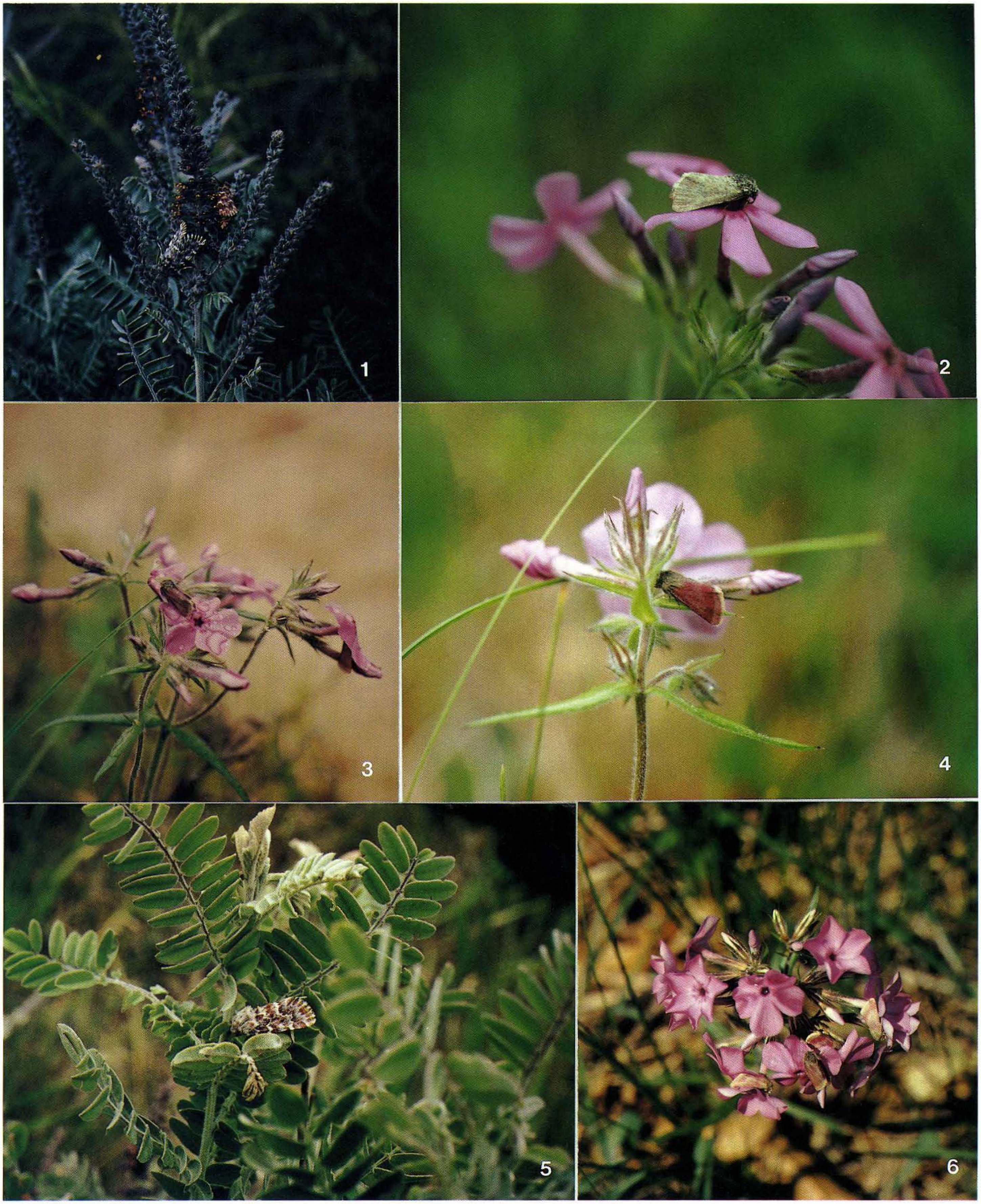

Plate 1. **1)** Two color forms of *S. lucens* on the same open inflorescence of the host (*Amorpha canescens*): a reddish form on the lower right, a purplish form on the lower left; 4 July 1995, Sheyenne National Grassland, Ransom County, North Dakota. **2)** A worn individual of *S. indiana* on a bright pink flower of the host (*Phlox pilosa*); 2 June 1998, Jackson County Forest, Wisconsin. **3)** An unhidden and a hidden individual of *S. indiana* on the same host inflorescence: the unhidden individual is on top of a central flower, the hidden individual on the underside of the far right flower; 6 June 1995, Jackson County Forest, Wisconsin. **4)** An individual of *S. indiana* perched on a host leaf, not a host flower; 6 June 1995, Jackson County Forest, Wisconsin. **5)** An individual of *S. lucens* perched on a host leaf, not a host flower; 4 July 1995, Sheyenne National Grassland, Ransom County, North Dakota. **6)** Four individuals of *S. indiana* perched on the same host inflorescence, in a row across the bottom tier of the inflorescence as viewed from above; 6 June 1995, Jackson County Forest, Wisconsin.

Plate 2. **7)** An *S. indiana* site in Minnesota (Staffanson Prairie, Douglas County), with pink flowers of the host (*Phlox pilosa*) in the foreground, 8 July 1992. **8)** An *S. indiana* site in Wisconsin (pine-oak barrens in Jackson County Forest), with pink flowers of the host (*Phlox pilosa*) in the foreground, 26 May 1998. **9)** An *S. lucens* site in Minnesota (Bluestem Prairie, Clay County), with purple flowers of the host (*Amorpha canescens*), 8 July 1990. **10)** An individual of *S. lucens* well camouflaged in the center of the picture on unopened flower buds of the host; 4 July 1995, Sheyenne National Grassland, Ransom County, North Dakota.

vicinity of Chicago (Hardwick, 1958). Our span of 2-8 July in Minnesota is slightly later than the dates for the two specimens reported by Balogh (1987): 16 June 1976 and 27 June 1978.

The flight period in this study for *S. lucens* from 30 June to 21 July in Wisconsin, and 3-10 July in Minnesota and North Dakota, is similar to numerous other reports during 1979-97. The earliest Wisconsin report was on 13 June 1987, the latest on 26 July 1993, with most reports falling between 23 June and 21 July (TLS, 1980, 1983-85, 1988-89, 1991-97). Reports from Illinois tended to be only slightly earlier, including the earliest date on 12 June 1987 and the latest on 28 July 1979, with the remainder between 20 June and 14 July (TLS, 1980-82, 1988-92). The reports from Michigan were from 26 June to 2 July (TLS, 1989, 1992), one report from Iowa was on 28 June 88 (TLS, 1989), and a single record from Nebraska was on 29 June 1991 (TLS, 1992). The flight period for *S. lucens* appears fairly similar over a rather large geographic area, primarily from late June into mid-July. Covell (1984) listed the flight period as June-July, except for April-May in Florida. Hardwick (1996) reported flight sometime between the second week in May and the second week in August, depending on latitude and altitude, for a very broad geographic range from northern Baja California to southern Canada.

Hardwick (1958) commented that the reddish-purple coloring on the forewings of *S. indiana* is darker than that of the fresh host blossoms on which they rest, much more closely resembling the color of a partially dried corolla about to drop from the plant. This was consistent with his observation that the forewing coloration of *Schinia florida* (Guenée) includes yellow and pink, the hues of fresh petals and dried corollas, respectively, of its host evening primrose (*Oenothera biennis* L.) (Onagraceae) (Hardwick, 1958). Likewise, the wings of *S. lucens* are similar in color to its host inflorescences when wilted and developing seeds (pers. obs.). However, much of the flight period of both *S. indiana* and *S. lucens* occurs prior to the existence of many, even any, dried corollas or wilted inflorescences. If individuals are present at that later phenology, they may be so worn that the original camouflaging may no longer be apparent, especially for *S. indiana*, which is whitish when very worn (Plate 1, Fig. 2). *S. lucens* is well camouflaged when perched on unopened host flower buds (Plate 2, Fig. 10). Buds of *P. pilosa* may be rather dark pink when coloration first develops, requiring us to look more closely to distinguish this from the forewing of *S. indiana* (pers. obs.). The coloration of *S. indiana* may afford more camouflage within host inflorescences amongst a mix of buds, flowers, sepals, pedicels, and shadows, than on the dorsal surface of a fully opened host flower. The coloration of these two *Schinia* species may correspond more to the host coloration when both flower buds and open flowers are present.

Weather, Time of Day, and Behavior

Even though we found individuals of both species under a wide range of weather conditions, we avoided continuing our searches once it was apparent that individuals had become quite active and would flush readily. As a result of this bias, absences (i.e., failures to detect individuals) would be relatively less represented in our surveys during weather conditions when the species are more active. However, we have documented that individuals of these species can be successfully found and even photographed in weather when they would likely be active and prone to flush, although we were particularly mindful at such times not to disturb them. Our data on hidden and unhidden perches would also be somewhat biased in that we didn't search host plants as thoroughly (i.e., we omitted hidden parts) during conditions when individuals would likely be quite active and prone to flush. Thus, individuals perched in an obscure location during very warm weather would less likely be detected. However, resightings of the same *S. indiana* individual later in the day anecdotally confirmed that individuals tend to move to more unhidden perches later in the morning and at warmer temperatures. A long period of seemingly inactive basking occurs early in sunny mornings, during which seemingly inactive individuals have actually moved sufficiently to improve the effectiveness of their perch for basking. Observation of the more active behaviors of these species, especially *S. indiana*, appears strongly limited given that they tend to flush quickly and are difficult to track in flight.

Hardwick's (1958) observation that *Schinia* species well camouflaged to their host flowers could be found at almost any time of the day resting on host blossoms was certainly the case in our observations of these two species. Hardwick (1958) did not treat *S. lucens*, but his statement (applied to *S. indiana*) that the adults were very inactive, resting most of the day on or among host blossoms, certainly seems accurate for *S. lucens*. Other Wisconsin lepidopterists have observed that *S. indiana* becomes very active on relatively warm and sunny days (Maxwell and Ferge, 1994). In our observations, *S. indiana* was completely inactive early (and presumably late) in the day and at cold temperatures. Individuals of *S. indiana* were active during the main daylight hours and when warm, yet we found individuals perched on host flowers during a wide range of times of day and temperatures. Likewise, Byers (1989) reported that individuals of *S. masoni* (Smith), very well camouflaged on flowers of its host, blanketflower (*Gaillardia aristata* Pursh) (Asteraceae), were usually found on host flowers during the day, either on top of the disk or under the rays. A bit differently from our study species, this *Schinia* became most active in late afternoon or early evening.

All individuals we observed of both species were associated with their host plant, with multiple individuals clustered on the same plant, even the same stem, in a highly nonrandom frequency. Others also typically reported these species on the host when observed undisturbed on a perch (TLS, 1980, 1983-84, 1988-89). The only record known to us of either species seen or taken from a plant not the host was a specimen of *S. indiana* collected by Ellen Ordway on 27 June 1978, labeled as "on *Heliopsis helianthoides* (L.)" (Asteraceae) (Balogh, 1987), a herbaceous yellow-flowered composite frequented by nectaring butterflies (pers. obs.). No records of *S. lucens* on a perch other than the host are known to us, although the species has been found at ultraviolet light traps, i.e., off the host (TLS, 1983-84).

Variation in Numbers Among Years

This analysis (Fig. 6) for *S. indiana* should be interpreted with caution. While the abundance indices (individuals/hour per survey per sampling area) for 1994-95 were based on a number of days of survey effort, the indices for 1996-98 derived from less survey effort on fewer days (Fig. 1). Since the indices for 1996-98 are less robust than for 1994-95, it would certainly be premature to interpret any long-term trend from this, especially since relatively few years are included in this analysis. Furthermore, when enough years of data are available to analyze trend, another bias will have to be considered. It is highly likely that the first year in such an analysis will be "good" (i.e., high in abundance). Before scientists can study a species, they must demonstrate success at finding the species, much more likely to occur in a "good" year. Certainly this was the case for us. If all our initial attempts to survey for *S. indiana* had occurred in "bad" (low abundance) years, we would not have persisted in our searches long enough to find an individual, and so would have abandoned any attempt to study the species before we even got started. However, since we conducted the surveys in 1996-98 at the phenological timing, in weather conditions, and timing during the day when peak surveys occurred in 1994-95, we believe this analysis is sufficiently valid to indicate that considerable variation occurs among years in abundance of this species. That is, findability at the right times and places in right conditions varies greatly among years. An example of how difficult the species can be to find during its flight period is the single individual found after seven hours of searching in a known area (TLS, 1987).

Site Characteristics

Similar to our findings, others have noted the association of *S. indiana* with *Lycaeides melissa samuelis* in range of this butterfly, in Montcalm County, Michigan (Balogh, 1987); Eau Claire County, Wisconsin (Masters and Karpuleon, 1975 cited by Balogh, 1987), and at the type locality in Indiana (Kwiat, 1908 cited by Balogh, 1987).

Since mature larvae in this subfamily often pupate promptly underground (Hardwick, 1958, 1996), both *S. indiana* and *S. lucens* are presumed to do so as well. Nonetheless, it would be very valuable to verify the typical pupal location for these species in nature. If sufficiently underground, then during the period of pupation (a part of the growing season and all the dormant season), land use and management activities would appear to be unlikely to affect the survivorship of the *Schinia* individuals themselves. Based on numbers we observed, such managements would appear to include light grazing, late-season mowing or haying, and especially for *S. lucens*, dormant-season burning. For *S. indiana*, eggs reared at room temperature hatched in 3-6 days, with larvae reaching a prepupal condition and location in a mean±SD of 14.6±5.9 days (Hardwick, 1958). Pupation in the subfamily typically occurs in about 5 days after that (Hardwick, 1996). Assuming females lay eggs during most of the flight period, their progeny should be pupae by about a month after the end of the flight period and should remain so until the next flight period the following year. Comparable information for *S. lucens* was not available, but the species appears univoltine widely throughout its range (Covell, 1984), thus overwintering as a pupa, and eggs of species in the subfamily typically hatch after several days, with larval feeding complete in about 2-4 weeks (Hardwick, 1996).

No indirect consequences for these *Schinia* populations would be likely if the land use or management activities are also compatible with maintaining healthy populations of the host and do not affect availability of host inflorescences when the *Schinia* individuals require them. It is beyond the scope of this study to address the long-term effects of management on host populations. The primary time that *Schinia* individuals would appear directly vulnerable to habitat management activities would be during the portion of the growing season when the adults and immature stages require flowering and seeding inflorescences of the host. Burning or mowing/haying at this time would remove these inflorescences from use. Such actions immediately prior to when the *Schinia* species require them would also delay host phenology relative to the *Schinia* phenology.

Applications for Survey Techniques

The ideal time of day to find these *Schinia* species, especially *S. indiana*, would seem to be under timing and weather conditions when they are likely to be less active but also in less concealed perches (i.e. basking). We favored early to mid-morning on sunny days for *S. indiana* searches, while *S. lucens* seemed equally findable under warm conditions from morning to afternoon. When one individual is found, it is advantageous to look on the same plant for another individual, even if hidden.

Searches for *S. indiana* are nonetheless arduous. Even though many individuals perched in a location that was technically in plain view, they are very small and easily overlooked animals. We found it beneficial to search either bent over or on our hands and knees. To find hidden individuals, it was often necessary to manipulate the host gently, so as not to damage the plant or dislodge any moths. Eye strain could be a problem, as the proximity required for these searches could place the observer so close as to be around the limit of binocular near focus for human eyes (i.e., the threshold for double and fuzzy vision). By contrast, searches for *S. lucens* were less arduous since the host plant is taller and less obscuring and the moth larger. The physical challenges are compounded in years of low numbers by the difficulty of maintaining willingness to persist with the search when few or no individuals have been found.

Several forms of systematic surveying have been used for moths not sampled by bait traps. Munguira and Thomas (1992) used the butterfly transect method (Pollard, 1977) for diurnal burnets (Zygaenidae). The species surveyed have wings with bright red and black marks which mimic various beetles (Order Coleoptera) and froghoppers (Homoptera: Cercopidae) (Krizek *et al.*, 1995). The butterfly transect method appears particularly well suited to apply to day-flying non-cryptic moths. Spalding (1997) adapted this same butterfly transect method for formal monitoring of another noctuid, *Luperina nickerlii leechi* Goater. Although nocturnal, the species has some parallels with these *Schinia* species. At least in the population monitored, the adult moth rarely flies and is most often found perched on its single host plant (a grass). Spalding (1997) used a searchlight to count perched individuals on the first pass along a fixed transect route, using the return pass along the same route to net and count flying individuals. Since these *Schinia* species are difficult to track in flight, a monitoring scheme for them should rely on detecting and counting perched individuals. Our less rigorous but related survey method used timed searches that did not follow fixed routes but instead moved from host to host, which may be clumped in distribution in the habitat patch. This is useful in that it concentrates survey effort in the places where the species is most likely to be found, and affords flexibility for variation in location of host in the proper flowering phenology among visits. If these *Schinia* species can be reliably found on fixed transect routes, this would be a more rigorous method of monitoring these species.

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