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BUTTERFLY FAUNA AND PHENOLOGY IN A DRY FOREST OF THE MOTAGUA VALLEY, GUATEMALA

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ABSTRACT. Field surveys of butteflies were conducted during 14 months in a Guatemalan dry forest, which yielded 103 species in 79 genera from 18 subfamilies of six families, with *Cyanophrys miserabilis* (Clench, 1946) (Lycaenidae: Theclinae) as a new country record. A seasonal pattern was shown in which species richness reached a peak at the end of the rainy season and declined greatly in the dry season. Species composition also differed significantly between the two seasons. This is the first quantitative study on the butterfly phenology of a Guatemalan dry forest, which will provide a scientific baseline for future entomological and ecological research and for biodiversity conservation in these forests

Additional key words: Assemblage, Inventory, Neotropical, Seasonality, Species List

Guatemala has a high diversity of Lepidoptera, and its butterfly fauna has been investigated since the 19th century (Bates 1864–1865, 1866, Boisduval 1870, Godman & Salvin 1879–1901). Currently, there are nearly 400 species of Hesperiidae (Austin et al. 1998, Barrios et al. 2006) and approximately 700 species in the remaining families of Papilionoidea known from the country (Salinas-Gutiérrez et al. 2009, 2012, Salinas-Gutiérrez 2013), although there have been few intensive surveys in Guatemala (but see Austin et al. 1996) compared to other adjacent countries such as Mexico and Belize (e.g., Maza et al. 1989, 1991, Meerman & Boomsma 1993, Meerman 1999, Lewis 2001, Pozo et al. 2003, 2008, Shuey et al. 2005, Luis-Martínez et al. 2011, Llorente-Bousquets et al. 2014). These circumstances underline the significance of additional surveys in Guatemala to enhance our understanding of the Neotropical lepidopteran fauna.

Seasonally dry forests in Guatemala are an unusual ecosystem with high biodiversity (CONAP-ZOOTROPIC-CECON-TNC 2011). The Motagua Valley in eastern Guatemala has a unique fauna with a high level of vertebrate endemism (Campbell & Savage 2000, Ariano-Sánchez & Salazar 2007, 2015, Brodie et al. 2012, Vásquez-Contreras & Ariano-Sánchez 2016, Ariano-Sánchez & Campbell 2018), implying that it might also support a rich entomofauna, although very little research has been conducted on insects in that area. Our previous studies revealed that a small woodland (69 ha) of dry forest in central Guatemala (Los Cerritos Municipal Park; hereafter, Los Cerritos) harbored more than 150 butterfly species including several new records for the country (Yoshimoto & Salinas-Gutiérrez 2015, Yoshimoto et al. 2018), highlighting the importance of these habitats and the necessity of more surveys in other dry regions. Basic entomological studies in the Motagua Valley are needed to gain more knowledge of its fauna, which in turn will give us useful information for biodiversity conservation in these forests. Since Los Cerritos is located in the Chixoy Valley of which flora partly differs from that of the Motagua Valley as described in more detail below, the lepidopteran fauna might also be different between the two regions. Moreover, as both lepidopteran larvae and adults in dry forests can show clear seasonal patterns associated with dry and wet periods (e.g., Janzen 1987, 1993, Torres et al. 2009, Checa et al. 2014), quantifying seasonality and phenology can help provide broader insights into factors affecting temporal changes in butterfly communities.

Here we present a list of papilionoid species (including Hesperiidae; van Nieukerken et al. 2011) observed over 14-month period at a subtropical dry forest in the Motagua Valley. In addition, we implemented a quantitative monthly sampling to examine their seasonality and phenology. Considering that some seasonal patterns were detected in butterfly assemblage of Los Cerritos (Yoshimoto et al. 2018), it is worth identifying such patterns quantitatively in that of the Motagua Valley, which may also contribute to a comprehensive understanding of butterfly phenology of the Neotropical dry forests.

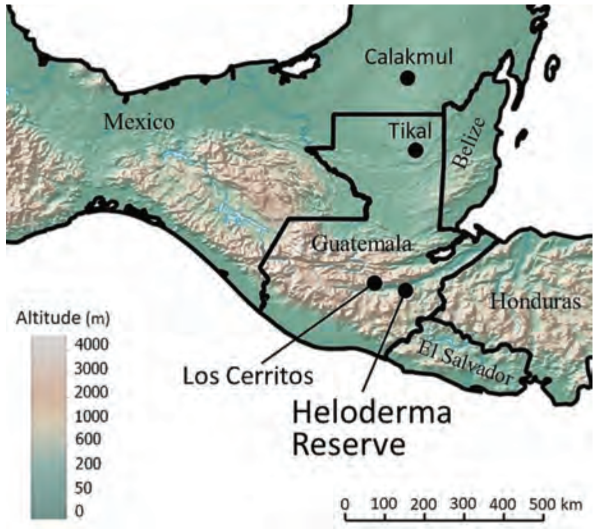

FIG. 1. Location of the Nature Reserve for the Heloderma Conservation (Heloderma Reserve). The study sites for the previous studies (Tikal National Park, Austin et al. 1996; Calakmul Biosphere Reserve, Pozo et al. 2003, 2008; Los Cerritos Municipal Park, Yoshimoto & Salinas-Gutiérrez 2015, Yoshimoto et al. 2018) are also shown on the map. Altitude of these regions is represented with the coloring patterns.

MATERIALS AND METHODS

Study site. This study was conducted in a woodland of the Nature Reserve for the Heloderma Conservation (hereafter, Heloderma Reserve; Figs. 1, 2) in Zacapa department in eastern Guatemala (89°47'W, 14°53'N, 510–790 m a.s.l., 58 ha), including on a neighboring farm road. Average annual precipitation for the years 2005–2009 at the nearest climatic station (Estación Pasabien) was around 900 mm (Ministerio de Comunicaciones Infraestructura y Vivienda -INSIVUMEH- 2018). The rainy season usually lasts from late May to October (Fig. 3); based on these rainfall data, we defined the six months from May to October as the rainy season and the remaining months (April, November–March) as the dry season. The vegetation of this region is subtropical dry forest or subtropical thorn forest (Cruz 1982), similar to habitats at Los Cerritos, ca. 63 km away from the Heloderma Reserve (Fig. 1; see Yoshimoto et al. 2018 for detailed information on Los Cerritos). Although both sites have abundant cacti (Cactaceae) such as *Stenocereus pruinosus* (Otto) Buxb., *Pereskia lychnidiflora* DC., and *Pilosocereus leucocephalus* (Poselg.) Byles & G. D. Rowley (Fig. 2c), there are some differences in flora in that the Heloderma Reserve is dominated by tall arboreal species such as *Bucida macrostachya* Standl. (Combretaceae), *Lysiloma divaricatum* (Jacq.) J. F. Macbr., *Leucaena collinsii* Britton & Rose (both Mimosaceae), and *Bursera excelsa* (Kunth) Engl. (Burseraceae) (Ariano-Sánchez & Salazar 2015, D. Ariano-Sánchez pers. com.), none of which have been reported from Los Cerritos (M. R. Álvarez pers. com.).

Sampling. We monitored butterflies for one day a month from April 2016 to March 2017 (12 days in total), observing adults along the short trail (1 km) of the Reserve and the neighboring farm road (ca. 700 m) for three hours in the morning (0900 h – 1200 h). When we were not able to identify butterflies on sight, we photographed or netted them to determine the species later; if we were unable to photograph or capture questionable species, we recorded observations at the genus level (see Appendix; we did not record individuals that we were unable to identify to genus). We did not record abundance data for all species observed; instead, we recorded abundance only when we encountered more than nine individuals (this

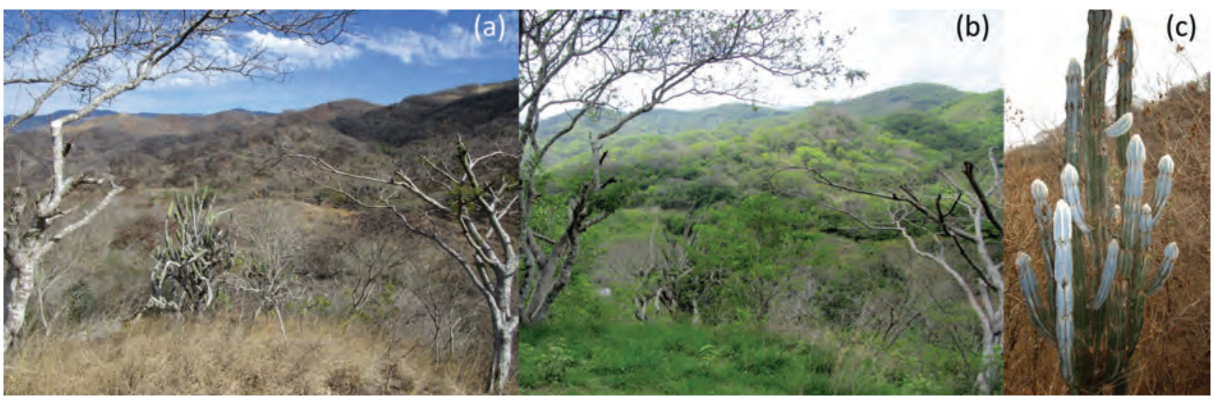

Fig. 2. Forest landscape of the Heloderma Reserve in the (**a**) dry and (**b**) rainy seasons, and (**c**) a columnar cactus *Pilosocereus leucocephalus* (Cactaceae).

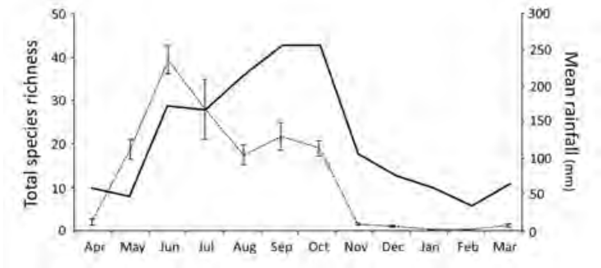

FIG. 3. Monthly species richness of butterflies observed at the Heloderma Reserve from April 2016 to March 2017 (solid line). Average monthly rainfall at Estación Pasabien in Zacapa in 2005–2009 is also shown with a broken line (the error bars represent standard errors), based on the data of Ministerio de Comunicaciones Infraestructura y Vivienda -INSIVUMEH- (2018).

criterion was arbitrary determined) for each species or genus during each sampling period. In addition to this semi-quantitative monitoring, we randomly collected or photographed butterflies at the Reserve and on the farm road from February 2016 to March 2017 in the daytime (0800 h – 1815 h); these qualitative surveys were done on 13 days, six of which are the same days as those when the semi-quantitative monitoring was done. These data, together with the 12-month-monitoring data described above, were used to compile a species list. The individuals collected were mounted and identified to species or subspecies according to Warren et al. (2017). All voucher specimens were deposited at the Laboratorio de Entomología Sistemática, Universidad del Valle de Guatemala.

Analyses. We calculated species richness based on our direct observations and by using the Chao index to estimate the total number of species and the proportion of species we directly sampled. To identify seasonal patterns, we conducted the following analyses using the monthly-monitoring data. For the taxa that were not identified to species on sight (the ones with species codes parenthesized; see Appendix), the data were pooled for each genus so as to be analyzed together with other identified species. To examine seasonal differences in species composition, we performed non-metric multidimensional scaling (NMDS) based on the similarity matrix using the Sørensen index. Analysis of similarities (ANOSIM) was also done to test for differences in species composition between the rainy (May–October) and dry season (April and November–March). ANOSIM is a multivariate analysis method based on nonparametric permutation using R values; R is 1 when all within-group similarities are greater than any between-group similarity, and R is close to 0 when similarities within and between groups are almost the same. (Clarke 1993). All the analyses were conducted using R 3.5.3 (R Development Core Team 2019) with the package Vegan (Oksanen et al. 2019).

RESULTS

During our 14-month surveys (19 days in total), we recorded 103 species (including three unidentified taxa and 58 subspecies) belonging to 79 genera, 18 subfamilies, and six families (Appendix). Nymphalidae was the most dominant family (38 species), followed by Hesperiidae, Pieridae, Lycaenidae, Riodinidae, and Papilionidae (35, 16, 6, 5, and 3 species, respectively). The estimated number of species (mean±SE) based on the Chao index was 137.62±14.27; we sampled an estimated 74.8% of the species inhabiting the Heloderma Reserve.

One hairstreak species (Lycaenidae: Theclinae) was recorded for the first time in Guatemala:

***Cyanophrys miserabilis* (Clench, 1946)**. GUATEMALA, Zacapa, Cabañas, Heloderma Reserve (89°47'W, 14°53'N, 510–790 m a.s.l.). One specimen: 24 October 2016, J508. Collected by Jiichiro Yoshimoto. Identified by Robert K. Robbins and Jiichiro Yoshimoto. The specimen was deposited in the Colección de Artrópodos, Laboratorio de Entomología Sistemática, Universidad del Valle de Guatemala, and is being cataloged (Fig. 4). Distribution: Southern Texas to Costa Rica (Warren et al. 2017).

Total species richness was higher during the five months of the rainy season (June–October) than in the dry season and May (Fig. 3). It reached a peak at the end of the rainy season (in September and October), being lowest in the middle of the dry season (in February).

FIG. 4. A butterfly species newly recorded for Guatemala; *Cyanophrys miserabilis* (Clench, 1946) (Lycaenidae: Theclinae). Dorsal and ventral views are shown at the left and right, respectively.

TABLE 1. Monthly species richness for six families of butterflies observed at the Heloderma Reserve from April 2016 to March 2017.

Family	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Papilionidae	2	2	2	0	0	1	1	1	0	0	0	2
Pieridae	4	4	9	7	9	7	7	4	4	5	2	3
Lycaenidae	0	0	1	1	2	1	4	2	0	0	0	0
Riodinidae	0	0	0	2	1	1	2	1	1	1	0	0
Nymphalidae	2	2	11	11	14	19	16	6	4	2	2	4
Hesperiidae	2	0	6	7	10	14	13	4	4	2	2	2

At the family level, similar seasonal patterns were shown in Nymphalidae and Hesperiidae; species richness increased greatly in June, reached a peak in September, and decreased sharply in November (Table 1). By contrast, species richness fluctuated differently among the other four families. In Pieridae, it did not vary greatly during the rainy season (excluding May), and this period had more species than the dry season. Lycaenid species were observed only from June to November, being richest (four species) in October. Species richness for Papilionidae and Riodinidae was much lower, with less than three species being observed per month.

The ANOSIM test detected a significant difference in species composition between the two seasons ($R = 0.464$, $P < 0.05$). Butterfly assemblages for June–October and for February–May each formed clusters on the NMDS ordination diagram (Stress = 0.094; Fig. 5), indicating that species composition was relatively similar within the rainy season (excluding May) and within the latter half of the dry season and May. By contrast, the plots were more scattered for November–January, representing higher variation in species composition among the former half of the dry season.

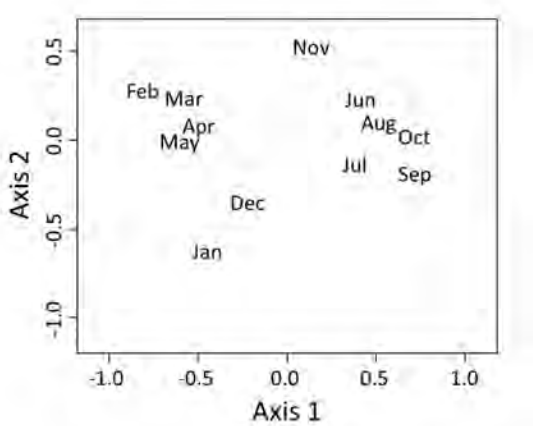

FIG. 5. NMDS ordination diagrams of butterfly assemblages sampled monthly at the Heloderma Reserve from April 2016 to March 2017.

Thirty-five species occurred in both rainy and dry seasons, whereas 60 species were observed only in the rainy season. The most dominant species was *Kricogonia lyside* (Godart, 1819) (Pieridae: Coliadinae: Fig. 6a), which was observed in 11 months (13 occurrences in total) with higher abundance (≥10 individuals) in May–July (Appendix). The second most dominant species was *Eurema daira eugenia* (Wallengren, 1860) (Coliadinae: in 10 months; ≥10 individuals in April, June, and August; Fig. 6b), followed by *Pyrisitia proterpia* (Fabricius, 1775) (Coliadinae: in nine months; ≥10 individuals in July–October; Fig. 6c), and *Cissia similis* (A. Butler, 1867) (Nymphalidae: Satyrinae: in eight months; Fig. 6h). At the genus level, *Hamadryas* (Nymphalidae: Biblidinae: Fig. 6d) occurred most frequently throughout the year, followed by *Eurema, Kricogonia, Pyrisitia* (all Coliadinae), and *Cissia* (Satyrinae), all of which were observed in 11 months.

DISCUSSION

Our field surveys yielded more than 100 butterfly species at the Heloderma Reserve, and the total species richness was estimated to be more than 130 species. As very little entomological research has been conducted in Guatemalan dry forests so far, the present study, together with our previous ones (Yoshimoto & Salinas-Gutiérrez 2015, Yoshimoto et al. 2018), add to our knowledge of the Neotropical butterfly fauna as well as provide a scientific baseline for biodiversity conservation in these

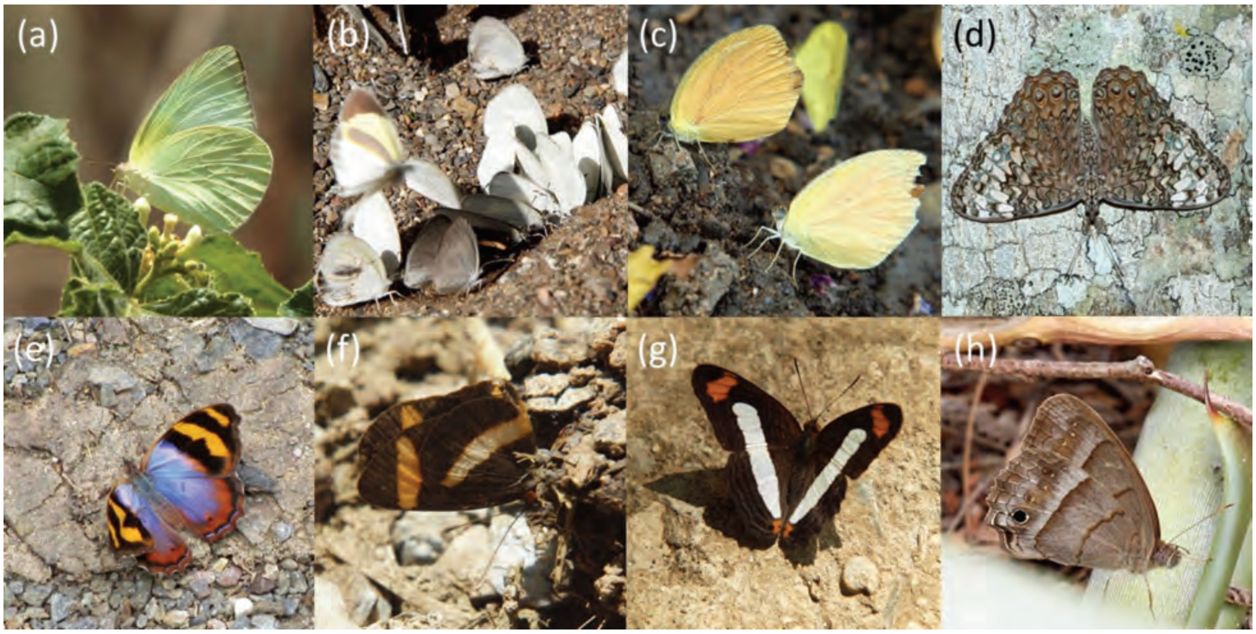

FIG. 6. Butterfly species that were commonly observed at the Heloderma Reserve: (**a**) *Kricogonia lyside*, (**b**) *Eurema daira eugenia*, (**c**) *Pyrisitia proterpia* (all Pieridae), (**d**) *Hamadryas glauconome glauconome*, (**e**) *Bolboneura sylphis sylphis*, (**f**) *Microtia elva horni*, (**g**) *Adelpha iphicleola iphicleola*, (**h**) *Cissia similis* (all Nymphalidae).

unusual dry forest habitats. The estimated species richness also indicates that we have yet to sample nearly one-fourth of the butterfly species inhabiting the Heloderma Reserve. More field surveys are necessary to make a more complete butterfly inventory of this site.

We recorded one hairstreak species, *Cyanophrys miserabilis*, for the first time in Guatemala. This species was collected from three of the neighboring countries (Mexico, Nicaragua, and Belize; Luis-Martínez et al. 2011, Robbins et al. 2012, J. Shuey unpublished), despite its possible wide distribution (Southern Texas to Costa Rica; Warren et al. 2017), representing that there is still a gap in our knowledge of its geographic distribution. Moreover, at Los Cerritos, we recently discovered two hairstreak species, *Atlides gaumeri* (Godman 1901) and *Michaelus hecate* (Godman & Salvin, 1887), both of which also constituted new records for the country (Yoshimoto & Salinas-Gutiérrez 2015, Yoshimoto et al. 2018), whereas these species are widely distributed in Mexico. All these results again underline the necessity of more research on butterflies in Guatemalan dry forests, especially on small and difficult taxa such as Theclinae.

One unexpected result was the collecting of *Piruna* (Hesperiidae) (one individual in June, one in August, and two in September) at the Heloderma Reserve, a dry lowland forest (510–790 m a.s.l.), because most species of this genus inhabit humid areas at higher altitude (1000–2700 m a.s.l.; Warren & González-Cota 1998). Although we were unable to identify the collected individuals to species, their wing patterns appear to be different from those of *P. aea aea* (Dyar, 1912) and of *P. brunnea* (Scudder, 1872), both of which should occur in Guatemala (Warren et al. 2017). These morphological differences suggest that our samples might represent a new record for the country or a new species, which must be verified by further research, ideally with DNA barcoding techniques.

Sixty-six and 70 species collected at the Heloderma Reserve were also sampled at Los Cerritos (Yoshimoto et al. 2018) and Tikal (Austin et al. 1996), respectively, with 46 species being shared among the three sites (Appendix). Although we cannot quantitatively compare the butterfly fauna among these sites due to considerable differences in sampling effort, it is intriguing that so many species of the Heloderma Reserve were also found at Tikal. This is a remote site (ca. 260 km away; Fig. 1) with very different environmental conditions, as noted previously in terms of the overlap in species between Los Cerritos and Tikal (Yoshimoto et al. 2018). On the other hand, there existed some marked differences in species composition between the two dry forest sites. In particular, Theclinae had fewer species at the

Heloderma Reserve than at Los Cerritos (3 vs. 20 species, respectively), whereas the opposite was true for Pieridae (16 vs. 14 species, respectively) and Pyrginae (15 vs. 12 species, respectively) despite the former site having fewer observation dates than the latter (19 vs. 109 days, respectively). Some differences in flora, such as vegetative structure and dominant plant taxa as mentioned in the study site section, may be a factor underlying the variations in the butterfly fauna between the two dry forest sites.

Species richness was much higher during the five months of the rainy season (June–October) than in the dry season and May, reaching a peak at the end of the rainy season. Since more than half of the component species was observed only in the rainy season, the occurrence of these seasonal species mainly contributed to the increase of total species richness in this period, and was responsible for the clear seasonal difference in species composition (Fig. 5). The great decline of species richness in the dry season is likely due to fewer food resources for their adults and larvae, such as flower nectar and leaves, caused by the defoliation of many plant species (Fig. 2). In the Guatemalan dry forests, May is a transitional period when the precipitation gradually increases (Fig. 3); continuous rainfall usually begins in late May as mentioned in the Introduction. These climatic conditions and associated plant phenology may be responsible for fewer butterfly species in this month (Fig. 3) and for its species composition similar to that for the late dry season (Fig. 5). Adults of many species present during the dry season may be in reproductive diapause, as reported in some lepidopteran species in a Costa Rican dry forest (Janzen 1987, Miller el al. 2007). Detailed examinations of their life history are necessary to support those conjectures.

Higher species diversity during the wet period has also been shown in other dry forests butterfly assemblages (Shahabuddin & Terborgh 1999, Checa et al. 2014, Yoshimoto et al. 2018), implying that this seasonal pattern is widespread in Neotropical seasonally dry forests. By contrast, species richness fluctuated very differently at two lowland forests in the region (Tikal and Calakmul; Fig. 1), which showed two peaks in both seasons and a decline at the end of the rainy season (Austin et al. 1996, Pozo et al. 2008). Those authors suggested that the duration and severity of dry period is the main factor for such variations in species richness. Our results would corroborate their hypothesis, considering that the dry season period is longer at our site (six months; Fig. 3) than at Tikal and Calakmul (three and four months, respectively). Multiple-year-monitoring is clearly needed to draw more robust conclusions of butterfly seasonality at our study site, which will also be helpful in making comparisons of seasonal patterns with other regions.

Seasonal variation also differed among the families; in Nymphalidae and Hesperiidae, species richness tended to increase gradually in the rainy season, whereas it remained relatively constant during the rainy season in Pieridae (Table 1). The seven pierid species (*Kricogonia lyside, Eurema daira, E. boisduvaliana, Pyrisitia proterpia, P. dina, P. nise*, and *Phoebis sennae*) occurred frequently in both seasons (≥ five months), indicating that these are aseasonal species having multiple broods throughout the year. It should also be noted that the genus *Cissia* (Nymphalidae: Satyrinae) was the only taxon whose abundance was much higher in the dry season (January, March, and April) and in May. This genus, in particular *Cissia similis* (A. Butler, 1867) (Fig. 6h), may have some reproductive strategy for the dry period, as reported in several satyrine species in an Australian savanna (Braby 1995); this issue would be worthwhile to examine further. Family-level fluctuations also differed notably from those observed at Tikal (Austin et al. 1996) and Calakmul (Pozo et al. 2008), although our limited sampling effort again prevents us from doing quantitative comparisons. As numerous environmental factors, including vegetation and microclimate, can influence butterfly assemblages (Checa et al. 2014), quantitative research in relation to such environmental variables is the next step towards a better understanding of seasonality and phenology of dry forest-inhabiting butterflies.

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APPENDIX

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APPENDIX. Butterfly species observed at the Nature Reserve for the Heloderma Conservation, Zacapa, Guatemala, from February 2016 to March 2017. Species collected and photographed are shown in bold and/or with an * asterisk , respectively. Taxa with species codes parenthesized are those which we were unable to identify on sight in the monthly monitoring (these data were excluded from the species count and the Chao index analysis). Species identifications were done according to Warren et al. (2017). Months with an * asterisk represent the cases in which more than nine individuals were observed. Months parenthesized indicate the cases in which the data were obtained only by the qualitative sampling (see MATERIALS AND METHODS). February and March are shown with the year information, since these months were sampled twice in different years.

Family Subfamily	Species and subspecies	Months when observed
Papilionidae		
Papilioninae		
1	*Heraclides cresphontes* (Cramer, 1777)* [A]	Oct
2	***Heraclides ornythion ornythion* (Boisduval, 1836)***	May, Jun
(1, 2)	*Heraclides* spp.	Apr, Sep, Nov, Mar'17
3	*Neographium philolaus philolaus* (Boisduval, 1836) [A,Y]	Apr, May, Jun, Mar'17
Pieridae		
Coliadinae		
4	*Anteos clorinde* (Godart, [1824])* [A,Y]	Jun, Aug
5	*Anteos maerula* (Fabricius, 1775)* [A,Y]	Jun, Jul, Aug, Sep, Oct
6	***Eurema boisduvaliana* (C. Felder & R. Felder, 1865)** [A,Y]	Jun, Jul, Aug, Sep, Oct, Nov
7	*Eurema daira eugenia* (Wallengren, 1860)* [A,Y]	Apr*, May, Jun*, Jul, Aug*, Sep, Oct, Dec, Jan, Mar'17
8	***Kricogonia lyside* (Godart, 1819)*** [A,Y]	(Feb'16), (Mar'16), Apr, May*, Jun*, Jul*, Aug, Sep, Nov, Dec, Jan, Feb'17, Mar'17
9	*Phoebis argante* ssp. n [A,Y]	Jul
10	***Phoebis philea philea* (Linnaeus, 1763)** [A,Y]	Jul
11	***Phoebis sennae marcellina* (Cramer, 1777)** [A,Y]	(Mar'16), May, Jul, Aug, Sep
(9–11)	*Phoebis* spp.	Apr*, Oct, Dec, Feb'17, Mar'17
12	***Pyrisitia dina westwoodi* (Boisduval, 1836)*** [A]	(Feb'16), Jun, Oct, Nov, Dec, Jan
13	***Pyrisitia nise nelphe* (R. Felder, 1869)** [A]	Jun, Jul, Aug, Sep, Oct, Dec
(12, 13)	*Pyrisitia* spp.	Jun, Jul
14	***Pyrisitia proterpia* (Fabricius, 1775)*** [A,Y]	(Feb'16), Apr, May, Jun, Jul*, Aug*, Sep*, Oct*, Nov
15	*Zerene cesonia cesonia* (Stoll, 1790) [Y]	Jun
Pierinae		
16	***Ascia monuste monuste* (Linnaeus, 1764)*** [A,Y]	Jun
17	***Ganyra josephina josepha* (Salvin & Godman, 1868)** [A]	Oct, Jan
18	***Glutophrissa drusilla tenuis* (Lamas, 1981)** [A]	(Jun), Aug
19	***Itaballia demophile centralis* Joicey & Talbot, 1928**	Jan

Appendix (continued)

Lycaenidae		
Theclinae		
20	***Cyanophrys miserabilis* (Clench, 1946)**	Oct
21	***Strymon melinus franki* W. D. Field, 1938** [Y]	Oct
22	***Strymon rufofusca* (Hewitson, 1877)** [Y]	Aug, Oct, Nov
Polyommatinae		
23	***Cupido comyntas texana* (F. Chermock, 1945)** [A,Y]	Nov
24	***Hemiargus ceraunus astenidas* (Lucas, 1857)** [A,Y]	(Feb'16), Jun
25	***Hemiargus hanno hanno* (Stoll, 1790)*** [A]	Jul, Aug, Sep, Oct
Riodinidae		
Riodininae		
26	***Calephelis* sp.1**	Jul, Aug, Sep, Oct, Nov, Dec, Jan
27	***Emesis emesia* (Hewitson, 1867)*** [A]	(Jun), Oct
28	***Lasaia sula sula* Staudinger, 1888***	(Jun)
29	***Synargis mycone* (Hewitson, 1865)** [A,Y]	Jul
30	***Theope virgilius* (Fabricius, 1793)**[A]	(Feb'16), (Nov)
Nymphalidae		
Libytheinae		
31	***Libytheana carinenta mexicana* Michener, 1943*** [A,Y]	Jun*, Aug*, Sep
Danainae		
32	***Danaus eresimus montezuma* Talbot, 1943*** [A,Y]	Jun, Aug
33	***Danaus gilippus thersippus* (H. Bates, 1863)** [A]	(Mar'16)
(32, 33)	*Danaus* spp.	Jul, Sep, Mar'17
34	*Lycorea halia atergatis* E. Doubleday [1847]*[A]	Sep
35	***Mechanitis lysimnia utemaia* Reakirt, 1866** [A]	Aug
36	*Mechanitis polymnia lycidice* H.W. Bates, 1864 [A,Y]	Sep
Heliconiinae		
37	*Agraulis vanillae incarnata* (Riley, 1926) [A,Y]	Aug
38	*Dione juno huascuma* (Reakirt, 1866) [A,Y]	Jul
39	*Dryas iulia moderata* (Riley, 1926)* [A,Y]	Aug, Sep, Oct
40	***Euptoieta hegesia meridiania* Stichel, 1938*** [A,Y]	Jun, Jul
41	*Heliconius charithonia vazquezae* W.P. Comstock & F.M. Brown, 1950 [A,Y]	Jul, Oct
Limenitidinae		
42	***Adelpha iphicleola iphicleola* (H.W. Bates, 1864)*** [Y]	Jun, (Jul), Sep, Oct
(42)	*Adelpha* sp.[Ex]	Aug, Nov
Biblidinae		
43	*Biblis hyperia aganisa* Boisduval, 1836 [A,Y]	Sep
44	***Bolboneura sylphis sylphis* (H.W. Bates, 1864)*** [Y]	Jun, Jul, Sep, Oct, Mar'17
45	*Dynamine postverta mexicana* d'Almeida, 1952 [A,Y]	Sep, Oct
46	***Eunica monima* (Stoll, 1782)*** [Y]	(Mar'16), Jun*, Jul, Aug, Oct, Dec

Appendix (continued)

47	***Hamadryas atlantis atlantis* (H.W. Bates, 1864)*** [* Y]	(Jun), Jul, Nov
48	***Hamadryas februa ferentina* (Godart, [1824])*** [* A, Y]	(Feb'16), Oct
49	*Hamadryas glauconome glauconome* (H.W. Bates, 1864) [* Y]	(Feb'16), (Mar'16), Jun, Jul, Aug, Jan, Feb'17
(47–49)	*Hamadryas* spp.	Apr, May, Sep, Dec, Mar'17
50	***Mestra amymone* (Ménétriés, 1857)** [A, Y]	(Mar'16), Jul, Aug, Sep, Oct, Nov, Dec
51	***Temenis laothoe hondurensis* Fruhstorfer, 1907** [A]	(Oct)
Cyrestinae		
52	***Marpesia petreus* ssp. n** [A,Y]	(Jun)
Nymphalinae		
53	*Anartia fatima fatima* (Fabricius, 1793) [A,Y]	Sep, Oct
54	*Anthanassa* sp.[MULTI]	Sep, Oct
55	***Chlosyne lacinia lacinia* (Geyer, 1837)** [A,Y]	Jun, Jul, Aug
56	***Chlosyne theona theona* (Ménétriés, 1855)*** [Y]	Jun, Jul, Aug, (Sep)
(55, 56)	*Chlosyne* spp.	Sep, Oct
57	***Chlosyne melanarge* (H. Bates, 1864)***	(Aug), (Oct)
58	*Historis odius dious* Lamas, 1995* [A,Y]	(Jul)
59	*Microtia elva horni* Rebel, 1906* [Y]	Jun*, Jul*, Aug*, Sep*, Oct*, Nov
60	*Siproeta epaphus epaphus* (Latreille, [1813]) [A,Y]	Sep
61	*Siproeta stelenes biplagiata* (Fruhstorfer, 1907) [A,Y]	Aug, Sep, Oct
62	*Smyrna blomfildia datis* Fruhstorfer, 1908* [A,Y]	Nov
Charaxinae		
63	***Anaea aidea* (Guérin-Méneville, [1844])*** [A,Y]	Jun*, Aug, Oct, (Nov)
Satyrinae		
64	***Cissia pompilia* (C. Felder & R. Felder, 1867)** [Y]	Aug, Oct
65	***Cissia similis* (A. Butler, 1867)*** [A,Y]	Apr, May, Jun, Oct, Nov, Dec, Jan, Feb´17
66	*Cissia themis* (A. Butler, 1867)* [Y]	Jul, Dec, Feb'17
(64–66)	*Cissia* spp.	Apr,* May*, Jan*, Mar'17*
67	***Hermeuptychia hermes* (Fabricius, 1775)** [A,Y]	(Feb'16), Sep, Oct
68	*Morpho helenor* ssp. [A]	Sep
Hesperiidae		
Eudaminae		
69	***Achalarus albociliatus albociliatus* (Mabille, 1877)** [A,Y]	Oct, Nov
70	***Achalarus toxeus* (Plötz, 1882)** [A]	(Mar'16), Oct
(69, 70)	*Achalarus* spp.*	(Oct), Feb'17, Mar'17
71	*Astraptes anaphus annetta* Evans, 1952 [A,Y]	Jul
72	***Cabares potrillo potrillo* (Lucas, 1857)** [A]	Jun, Aug, Nov
73	***Cephise aelius* (Plötz, 1880)**	Oct
74	***Epargyreus exadeus cruza* Evans, 1952** [A,Y]	Aug
75	***Polygonus leo arizonensis* (Skinner, 1911)** [Y]	(Jun), Jul, Aug, Sep, Oct

Appendix (continued)

76	*Polythrix asine* (Hewitson, 1867)* [A]	(Oct)
77	***Proteides mercurius mercurius* (Fabricius, 1787)** [A,Y]	Sep
78	***Typhedanus ampyx* (Godman & Salvin, 1893)** [A]	Oct
79	***Urbanus dorantes dorantes* (Stoll, 1790)*** [A,Y]	Apr, Jun*, Jul, Aug, Sep, Oct, (Nov)
80	***Urbanus viterboana* (Ehrmann, 1907)** [A,Y]	Sep, Oct
Pyrginae		
81	***Antigonus corrosus* Mabille, 1878** [A]	Sep
82	***Antigonus erosus* (Hübner, [1812])*** [A,Y]	(Feb'16), Aug, (Oct), Mar'17
83	*Celaenorrhinus fritzgaertneri* (Bailey, 1880)* [Y]	(Mar'16)
84	***Chiomara georgina georgina* (Reakirt, 1868)** [Y]	Aug
85	***Gorgythion vox* Evans, 1953** [A]	Jun, Jul, Aug, Sep, Oct
86	***Grais stigmaticus stigmaticus* (Mabille, 1883)***	Jun, Jul
87	***Heliopetes laviana laviana* (Hewitson, 1868)** [A]	(Feb'16)
88	***Heliopetes macaira macaira* (Reakirt, [1867])** [A]	Oct
89	***Heliopyrgus domicella domicella* (Erichson, [1849])** [Y]	Sep
90	***Pyrgus oileus* (Linnaeus, 1767)*** [A,Y]	Jul, Aug, Sep, Oct, Dec
91	***Staphylus ascalaphus* (Staudinger, 1876)** [Y]	Sep, Jan
92	***Staphylus azteca* (Scudder, 1872)**	(Feb'16), Aug, Nov, Feb'17
93	***Timochares trifasciata trifasciata* (Hewitson, 1868)** [A]	Jan
94	***Zopyrion sandace* Godman & Salvin, 1896** [Y]	Apr, Sep, Dec
Hesperiinae		
95	***Atrytonopsis ovinia* (Hewitson, 1866)** [Y]	Oct, Dec
96	***Cymaenes tripunctus theogenis* (Capronnier, 1874)** [A]	Sep
97	***Lerema liris* Evans, 1955**	Jul, Sep
98	***Methionopsis ina* (Plötz, 1882)** [A]	Oct, Nov
99	***Perichares adela* (Hewitson, 1867)** [A, Y]	Oct
100	***Piruna* sp.1**	Jun, Aug, Sep
101	***Synapte shiva* Evans, 1955** [Y]	Jun, Dec
102	***Synapte syraces* (Godman, 1901)**	Sep
103	***Vettius fantasos* (Cramer, 1780)** [A, Y]	Oct

[A] Species shared with those collected by Austin et al. (1996).

[Y] Species shared with those collected by Yoshimoto et al. (2018).

[EX] Excluded from the species count and the Chao index analysis (but included in the seasonality analyses, together with the data for *Adelphia iphicleola*, after pooling the data for this genus), because these observed individuals were also likely to be of *A. iphicleola*.

[MULTI] These data might include multiple species, although we were unable to confirm it due to lack of the specimen sampling.