LUGGER, O. 1899. Fourth annual report of the entomologist to the state experiment station of the University of Minnesota, to the Governor, for the year 1898. St. Paul, Minn. 280 p.

MAXIMIZING DAILY BUTTERFLY COUNTS

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Early in 1967, a preliminary draft of a most interesting paper by Heinz Ebert came into my hands for initial comment. This paper (Ebert, 1970) provided me a great impetus toward the systematization of field collecting techniques, and the proper keeping of records. It was especially valuable in pointing out the great rarity of most species in southern Brazil (and probably in most of tropical America), the preponderance of small, inconspicuous, and/or highly localized butterfly species in the Neotropical fauna, and the advantages of having several collectors in an area at the same time to obtain more complete and representative recording of the species present.

I resolved to try to apply the conclusions of Ebert's paper towards a continuing study of the Lepidoptera of the central Brazilian plateau (see Brown & Mielke, 1967, 1968; Mielke, 1967, 1968a, 1968b). Initially, a complete written list was made of the species (including numbers of each sex) that were captured and positively observed in each collecting day. The following observation of Ebert (p. 6) provided an initial basis for the effort then made to maximize these daily lists:

"*In eastern Brazil the individual frequency of butterflies is generally very low.* The success of an excursion is exclusively determined by the number of species found. The higher the number of species found during a trip, the higher the chance to find some regionally (and/or individually) rare species. . . ."

This suggested that the maximization of daily species lists of butterflies, a seemingly unscientific goal (though much employed in a sister area, ornithology), could give a large scientific fallout; and this has indeed proved to be the case. For the benefit of the butterfly-interested public, both amateur and professional, this paper presents a discussion of the methods used for maximization and the results obtained, including a comparison of various Neotropical collecting areas, both in overall Rhopalocera and in individual family or tribal groups.

Although the collecting methods here described for obtaining maximum daily lists differ in many fundamental aspects from those used by Ebert in his careful long-term studies of the butterfly frequencies in Brazil (which place an emphasis on *averages* rather than on maximum daily lists), the overall results are very similar and further confirm Ebert's conclusions on intensive, extensive, and seasonal abundance of the various groups of Brazilian Rhopalocera. This paper thus represents a supplement to Ebert's full discussion, written from a different point of view, and incorporating data derived principally from about 150 collecting days in 1967–1972 (see Table 1 for a selection of these), with maximum expenditure of energy, using methods of intensive or large-scale area coverage, and efficiency and accuracy of recording, developed and sharpened during ten years of taking ornithological censuses.

METHODS

Equipment

It was ascertained early that the routine use of binoculars during the day's collecting (as in ornithology) not only greatly increased the number of butterfly species that could be positively recorded in a day, but also permitted a beneficial redistribution of energy: most larger common species, which could be unequivocally identified even to the sex at long distance with binoculars, did not need to be captured, and physical effort could be concentrated on collecting the smaller and more unusual species present. In general biological terms, the use of binoculars also allowed careful field studies of high-flying species and unusually wary forms or individuals, rarely mentioned in the lepidopterological literature. In a noteworthy case, the female of a new species of Ithomiinae was observed while laying eggs high in a tree; this observation led to publication of the complete biology of the species together with its original description (Brown & d'Almeida, 1970). Many other immature stages have been discovered in this same manner with binoculars. Also, the nearly extinct *Heliconius nattereri* was finally relocated, studied, and bred by the author following a chance long-distance sighting with binoculars of a male in Santa Teresa, Espírito Santo (see Brown, 1970, 1972).

An eight-foot pole length with a four-foot extension (for more open areas), easily manageable in all but the densest woods, is necessary to capture the many high-flying species (which generally belong to groups of localized and little-known forms, especially Lycaenidae[1] and Hesperi-

[1] We use the family Lycaenidae to cover the group often discussed as a superfamily, Lycaenoidea (in the Neotropics, the Plebejinae, Theclinae, and Riodininae). Likewise, Nymphalidae = Nymphaloidea of many authors.

idae), which can be discovered with binoculars but not always positively identified.

In addition to the binoculars and lightweight net with aluminum pole, minimal collecting equipment is kept (forceps, a belt box with envelopes, a small poison jar in the pocket) to permit rapid movements and efficient handling of captured specimens. Photographic and breeding equipment are left in a central location; early stages discovered are brought back there during "slack" collecting hours in the late afternoon.

Planning

In attaining a maximum list in a given region, or seeking to use a limited number of collecting days most effectively, the lepidopterist should work principally in relatively restricted and disturbed wooded areas (see below), and move around a great deal in the initial explorations. The area chosen must be well reconnoitered for paths and roads, streams and sandy banks, flowers inside and outside the forest, clearings within the woods which catch the sun at various times of the day, and accessible forest edges lit by the first and last sun in the day. The latter areas will provide the majority of the day's lycaenids, and the clearings and flowers the majority of the Hesperiidae. A partly cleared hilltop will provide dozens of additional species throughout the day in both these groups, plus many additional and unusual Papilios and Nymphalidae. Baited traps (as many as 30) should be placed along trails and on woods-edges on the evening or night previous to a collecting day. By using traps to capture the many bait-attracted nymphalines and satyrines (a number of which enter during the twilight and dawn hours), the collector can focus his attention on the smaller species which do not catch themselves so easily.

Collecting Period and Distribution of Energy

In the ideal case, weather and his strength permitting, the collector should work from sunup to dark, leaving the woods edge at sundown (when the Lycaenidae finally sit down for the night) to capture Brassolini at their suspected or prelocated flyways. Thus the condition of maximum effort may be fulfilled, giving the over-all results a measure of consistency. "Slack periods" in the early morning and late afternoon, or during cloudy spells, may be used for resting, moving between collecting areas, and harvesting the traps. In very hot lowland tropical areas (the coastal plain in southeast Brazil in summer, much of the Amazon Basin near the rivers, or lowland Panamá) both butterflies and collectors are often driven into inactivity by the heat between 1100 and 1430; but in

hilly or mountainous regions, both can remain active during most of the daylight hours, with peaks in late morning and mid-afternoon.

A single collector, for best maximization, should move rapidly from habitat to habitat (using a vehicle such as a Jeep to cover greater distances), collecting a number of times during the day in each subarea of the locality chosen. On the other hand, a party of collectors will get more results and tire less during the day if they divide up the locality, each covering one biotope or contiguous area very thoroughly during the entire day.

In view of the great preponderance of small-sized Hesperiidae and Lycaenidae in the Brazilian butterfly fauna (see Table 1, end), the effort to maximize lists requires a heavy concentration on these often ignored groups, using binoculars to locate high-perching individuals and spending much time collecting the many species that visit flowers. As Ebert (1970) has noted, the vast majority of the species in these two families have a very low intensive frequency; even in areas where over 300 species in each family have been recorded over long periods, the maximum day's list under optimal conditions rarely passes 100 species in either family. Casual (non-maximized) collecting usually yields but 10–40 species of Lycaenidae or Hesperiidae in a day; concentration on these groups can raise the levels to 30–80 or more (see Table 1).

RESULTS

The comparison of results obtained in completing the list for the central plateau before and after the adoption of these methods is instructive. In six weeks' collecting in the planalto, before the use of the maximization method, the author and Nirton Tangerini added only 25 species to the total published list (Brown & Mielke, 1967). Using the methods to maximize daily lists, and thereby collecting preferentially the less noticeable species, the author with Stan Nicolay or Karl Ebert added nearly 300 species to the list in another six weeks' collecting in 1967–1970. The total list for the planalto is now over 950 species (see Table 1); most of the added species are small or inconspicuous forms (Satyrinae, Lycaenidae, and Hesperiidae) which probably would have been passed over in casual collecting.

In two weeks' collecting in Belo Horizonte using these methods in May 1967 (the first real test of maximization), the author added 145 species to the published list for the area (Brown & Mielke, 1967). On one sunny day, 260 species of Rhopalocera were positively identified, over 90% of these being caught.

On the local scale, the maximization method could be used to confirm

a fact well-known to Neotropical lepidopterists but often misunderstood in other areas: the most rich and, surprisingly, often most representative collections are to be made in highly restricted areas of partly cut forest, surrounded by fields and swamps, preferably with many low flowers, and liberally served by paths, roads, and clearings. While the legendary (and often imaginary!) areas of vast virgin tropical forest invariably harbor many unusual and characteristic species, these tend to occur in very low density throughout the forest, and must seek sun at levels unattainable by the collector's net. The best overall collecting is always in small varied woodlots where most species thrive and remain accessible.

On the regional scale (see Table 1), the maximization method revealed that the largest intensive species frequencies for daily lists (though not necessarily for long-term censuses), could be found in the blend zones between the cerrado area of the Brazilian planalto and the adjacent tropical forests of the southeast coastal mountains (as in Belo Horizonte or Poços de Caldas) or the Amazon Basin to the north. The rarer species seemed to be more common in these areas, probably because of the highly varied microclimates and floral niches present in the hilly transition areas between different faunal regions.

In the northwestern blend area between the cerrado and the upper middle Amazon region in central Mato Grosso, preliminary application of these methods in the summer of 1969 suggested that intensive winter collecting might give lists approaching the limits of daily butterfly numbers for the Neotropics. Therefore, when in May 1969 an excursion to the Chapada de Guimarães was made in company with Stan Nicolay, full plans were developed for intensive collecting with maximization methods, both along the way and in the Mato Grosso blend area. The results of this trip (see Table 1) amply confirmed the exceptional position of the Chapada de Guimarães in central Mato Grosso with respect to relative butterfly abundance. This area produced in one day a list of 361 species (307 recorded by the author alone), which, for the time being, stands far above the daily lists obtained by us or others in any other area of the Neotropics or, indeed, in the rest of the World.[2]

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[2] The late Dr. Richard M. Fox claimed to have collected "about 350" species in a single day's collecting near his field station in Liberia (personal communication). As he reports only 450 species for the whole country (Fox, Lindsay, Clench & Miller, 1965), we must conclude that, unless the percentage of rare and localized species in the Liberian fauna is vastly lower than that in the Brazilian fauna, this estimate may be somewhat exaggerated. The author also has a letter from John H. Masters indicating that a list of 350 would be attainable in a single day's collecting in the Amazon Basin. We presume that this would be in the blend areas on its western edges, where the highland and basin faunas meet and mix. The author has visited a number of such areas in Colombia, Peru, Ecuador, and Bolivia; several of them offered the same subjective impression of extreme butterfly abundance that is evident in central Mato Grosso.

A day's total of 350 should be near the limit for a single collector even in such exceptionally rich areas, not due so much to butterfly abundance as to limitations on the speed of moving between ecological niches, and observing, collecting, and enveloping specimens. In some exceptionally varied blend areas on the borders of the Amazon Basin, a party of three or four collectors might be able to pass the limit of 500 species in a single day.

TABLE 1. Comparisons of some daily counts made with intensive methods in central and southern Brazil, 1967 to 1972 * = estimated number (± 5%), material not fully classified.

Locality	Date	Weather	Flowers	No. col.	Butterfly Groups MO	BR	SAT	DA	ITH	AC	HEL	NYM	LIB	THE	PL	RIO	PIE	PA	HESP	TOTAL
Sumaré, Rio de	28-III-68	Cloudy, warm	+	2	4	5	9	2	7	4	8	33	0	10	2	7	15	5	63	174
Janeiro (Parque	9-IV-68	Clear, cold, windy	++	1	2	5	9	1	7	4	8	39	0	16	2	11	15	3	84	206
Nacional da	30-IV-69	Clear, cool	+	2	2	4	3	0	1	2	8	27	0	32	0	8	7	5	30	129
Tijuca): Disturbed	10-V-69	Clear, warm	+	2	2	1	6	1	7	5	10	29	0	21	0	19	10	5	43	159
(mostly second-	19-VI-67	Clear, warm	++	1	1	5	6	1	13	3	10	41	0	19	2	23	18	2	62	206
ary) steep forest,	9-VII-68	Clear, hot	+	2	1	1	7	0	2	2	9	29	0	20	1	15	16	4	59	166
humid canyons,	31-VII-67	Clear, warm	+++	3	0	6	6	0	9	1	10	46	0	21	1	27	16	4	86	233
trails and roads;	8-VIII-68	Cloudy, warm	+++	1	1	3	7	0	3	3	9	21	0	13	0	15	14	1	78	168
includes good	12-VIII-67	Partly cloudy	+++	1	1	3	6	0	9	1	9	41	0	16	2	19	13	3	88	211
hilltops.	13-VIII-69	Partly cloudy	+++	1	0	8	8	0	6	4	8	45	0	24	0	25	16	5	107	256
	15-VIII-70	Clear, warm	+++	1	0	2	7	0	1	2	9	29	0	17	1	17	14	3	68	170
	14-VIII-71	Clear, warm	+++	1	0	7	10	2	10	5	10	37	0	28	1	25	20	5	118	278
	28-VIII-67	Clear, hot, dry	++	1	1	5	8	0	10	1	10	48	0	20	2	20	14	9	81	229
	16-IX-67	Clear, cold, dry	+	1	1	4	10	0	8	1	9	45	0	20	0	16	11	5	62	192
		NOTE: Peak in midwinter flower season. Large differences between 1967 and 1969 (good years) and 1968 and 1970 (bad years); 1971 extremely good. General abundance of Hesperiidae.																		
TOTALS for Sumaré, 40 collecting days					5	13	21	3	29	6	16	75	1	100*	3	80	36	20	250*	658
Vila Velha, Ponta Grossa, Paraná: Subtropical forest, open fields, marshes.	6-II-68	Clear, warm	+	2	2	4	13	0	6	0	5	11	0	9	1	8	4	3	28	94
Curitiba, Paraná: Subtropical forest, swamp.	7-II-68	Clear, warm	+++	2	1	5	8	0	5	1	7	22	0	4	2	5	12	5	48	125
		NOTE: Peak in midsummer. Generally much reduced fauna of these temperate forests, which experience frosts in winter.																		
Xerém, state of Rio	11-IV-67	Clear, hot	+++	1	3	3	9	2	16	4	11	34	0	7	1	10	19	4	50	173
de Janeiro:	13-IV-67	Clear, hot	+++	1	3	0	9	2	15	3	9	35	0	7	1	13	19	5	46	167
Heavy humid	30-VII-68	Clear, hot, dry	+	3	1	0	12	0	21	1	9	41	0	18	1	15	16	3	39	177
forest, mostly	16-IX-68	Clear, hot	+	1	1	0	16	1	17	2	8	44	0	17	1	17	15	3	29	171
virgin, canyons	18-IX-67	Clear, hot	+	1	1	4	12	1	13	1	10	51	0	7	2	18	17	11	31	179
& streams at	19-IX-68	Clear, hot	+	1	1	2	15	1	22	1	9	44	0	10	0	21	20	6	36	188
foot of moun-	25-IX-68	Clear, warm	+	1	1	3	14	1	21	1	8	40	0	5	0	24	16	4	42	180
tains.	30-IX-67	Clear, hot	+	1	1	5	15	2	16	0	10	50	0	7	2	9	11	8	23	159
	1-X-67	Clear, hot	+	1	1	7	16	2	19	2	10	46	0	5	3	11	17	12	16	167
	3-X-67	Clear, hot, dry	+	1	1	5	14	3	16	1	10	60	0	12	2	16	12	9	25	186
		NOTE: Peak in late winter and early spring, *before* heavy rains of October; secondary peak in April flower season. Abundance of Nymphalidae, scarcity of Lycaenidae/Hesperiidae.																		
TOTALS for foothill forests near Rio, 15 days					6	14	31	3	33	6	16	80	1	40	3	60	35	24	130	482

TABLE 1. (*Continued*)

Locality	Date	Weather	Flowers	No. col.	Butterfly Groups MO	BR	SAT	DA	ITH	AC	HEL	NYM	LIB	THE	PL	RIO	PIE	PA	HESP	TOTAL
Magé, st. R.J.: Lowland humid forest, swamps.	3-VII-68	Clear, warm	+++	1	1	1	7	1	9	1	6	32	0	12	3	4	16	5	41	139
Tiuma, Pernambuco: Moist tropical forest.	2-VIII-70	Clear-rainy, hot	++	1	1	5	18	2	4	0	8	36	0	2	0	13	10	0	11	110
Independência,	13-II-68	Clear, warm	+	2	2	3	5	2	1	0	6	12	0	12	1	4	12	12	18	90
Petrópolis, state	31-I-69	Clear, warm	+	3	2	2	4	1	0	1	9	12	0	4	0	2	7	3	15	62
of R.J.: Hilltop in montane forest.	1-V-69	Part cloudy, cool	+	2	0	1	7	0	2	0	3	6	0	15	0	6	5	2	37	84
		NOTE: Generally depauperate daily fauna, though fairly rich total fauna, of this high, cool region. Much variety in the smaller species. Peak in midsummer (warmer season).																		
TOTALS for mountain forests near Rio, 28 days					8	10	32	4	26	8	12	83	1	60	2	54	37	18	120*	475
Santa Teresa,	11-II-69	Clear, hot	+	2	3	4	10	2	12	1	11	24	0	5	0	11	12	0	23	118
Espírito Santo:	12-II-69	Clear, hot	+	2	1	5	15	0	10	1	9	28	0	7	1	12	11	3	19	122
Heavy, steep	20-II-69	Part cloudy, warm	+	1	1	4	17	0	9	0	7	22	0	8	0	15	13	2	25	123
virgin forest,	22-II-69	Cloudy, warm	+	1	3	4	9	1	13	1	10	20	0	3	1	14	11	1	23	114
cold in winter,	23-II-70	Part cloudy, warm	+	2	3	5	9	1	12	1	11	22	0	3	0	16	10	3	23	119
hot in summer.	24-II-69	Part cloudy, hot	+	1	3	4	11	1	15	1	10	19	0	5	0	20	13	1	32	135
	25-II-69	Part cloudy, hot	+	1	3	6	11	0	13	2	10	22	0	10	0	19	12	1	28	137
	26-II-69	Part cloudy, warm	+	1	2	4	18	0	6	1	8	23	0	6	0	9	14	4	24	119
	29-III-70	Clear, warm	+	2	4	4	17	3	5	5	13	25	0	6	1	17	14	1	23	138
	1-IV-69	Part cloudy, hot	+	1	5	8	13	0	10	7	8	21	0	3	1	12	10	0	24	122
	2-IV-69	Clear, warm	+	1	5	5	13	1	7	6	8	28	0	3	0	8	9	0	13	106
	19-IV-69	Part cloudy, cool	+	1	3	3	9	0	8	5	8	20	0	4	0	10	11	3	15	99
	9-VI-69	Clear, cool	+	1	1	0	9	2	1	1	5	12	0	4	3	12	8	0	13	71
	10-VI-69	Clear, warm	+	1	1	0	8	1	7	0	11	13	0	4	2	7	9	2	18	83
	15-VI-69	Clear, warm	++	1	1	0	7	1	9	0	12	13	0	3	0	6	9	0	18	79
		NOTE: Peak in late summer, before first colder weather. Abundance of Morphos, Brassolini, Heliconiini; scarcity of Lycaenidae (especially Theclinae) and Hesperiidae.																		
TOTALS for Santa Teresa area, 100 collecting days					8	20	40	3	26	7	17	90	1	30	3	70	35	13	150*	513
Conceição da Barra,	23-VI-68	Clear, warm	++	2	2	2	15	2	12	1	9	22	0	8	0	14	9	0	41	137
Espírito Santo:	4-V-69	Clear, hot	+	2	3	0	10	0	6	0	8	24	0	14	2	18	10	1	40	136
Heavy dense virgin forest.																				
Pedro Canário,	27-VII-67	Clear, warm	+++	2	0	0	23	1	12	1	11	29	0	23	0	13	13	0	58	184
Espírito Santo:	20-VI-68	Clear, hot	+	2	1	1	26	2	14	1	10	23	1	18	2	10	15	0	48	172
Remnant of same forest, with flowering fields.																				
Mirassol, São Paulo: Semitropical deciduous forest.	5-IX-68	Clear, hot	+	1	0	2	9	1	18	1	3	29	1	4	0	8	11	0	23	110

TABLE 1. (*Continued*)

Locality	Date	Weather	Flowers	No. col.	Butterfly Groups MO	BR	SAT	DA	ITH	AC	HEL	NYM	LIB	THE	PL	RIO	PIE	PA	HESP	TOTAL
Araras, São Paulo: Deciduous forest as in Mirassol, but more humid.	31-V-69	Clear, hot	++	2	0	0	11	1	5	0	7	39	0	28	2	6	11	3	35	148
Barbacena, Minas Gerais: Restricted montane forest, blend zone.	5-V-67	Part cloudy, cool	+++	1	1	2	10	0	12	4	9	22	0	12	3	10	19	5	97	206
	11-V-69	Part cloudy, cool	+	2	0	0	11	0	4	3	7	14	0	39	2	11	21	2	60	174
Belo Horizonte, Minas Gerais: Blend zone forest, cerrado, fields.	1-V-67	Part cloudy, cool	++	1	1	2	7	3	11	3	10	44	1	18	4	15	22	6	83	230
	10-V-67	Part cloudy, cool	++	1	1	2	9	2	16	4	7	45	0	26	4	12	20	7	82	237
	13-V-67	Clear, warm	++	1	1	0	10	3	14	2	8	58	0	24	4	15	22	5	94	260
	18-V-67	Cloudy, cool	++	1	1	1	10	1	16	1	11	28	0	10	4	5	20	3	93	204
		NOTE: Peak in early autumn. Scarcity of Lycaenidae, especially Riodinidae; otherwise balanced.																		
TOTALS for Belo Horizonte, 10 collecting days				3	10	20	3	22	8	13	75	1	50	4	34	32	13	170	458	
TOTALS for Poços de Caldas, in the blend zone (similar to Barbacena and Belo Horizonte) 37 collecting days (Ebert, 1970)				5	7	34	4	21	7	9	76	1	84	3	47	35	16	223	572	
		(for purposes of comparison; note increase in small species)																		
Paracatú, Minas Gerais: Hilltop, cerrado.	5-V-68	Clear, warm	−	1	0	0	14	1	5	1	4	31	1	8	2	12	5	5	29	118
	13-V-69	Clear, warm	−	2	1	1	15	1	5	0	6	33	0	23	2	13	11	3	57	171
	15-XII-68	Part cloudy, warm	−	2	0	0	8	0	2	1	4	30	1	17	2	11	10	4	45	135
Mineiros, Goiás: Restricted headwater forest, fields, cerrado.	20-V-69	Clear, hot	+	2	1	0	17	1	4	1	4	29	1	49	2	21	9	0	61	200
	21-V-69	Clear, hot	+	2	2	0	24	1	3	1	3	27	1	37	2	23	12	0	65	201
Paraopeba, Minas Gerais: High humid forest.	2-III-68	Cloudy, warm	−	1	1	1	13	3	11	0	4	29	1	2	2	6	13	4	13	103
	3-V-67	Clear, warm	+	1	1	1	10	2	12	1	5	32	0	8	3	13	12	2	30	132
	3-V-68	Clear, warm	+	1	2	2	10	2	10	3	5	29	1	6	3	5	13	2	29	122
	4-V-67	Clear, warm	+	1	1	1	11	2	10	1	4	35	0	6	2	9	13	2	38	135
Curvelo, Minas Gerais: Same type of forest.	4-V-68	Clear, warm	+	1	1	0	14	2	9	1	4	22	1	7	2	10	10	2	27	112
	12-V-69	Clear, warm	+	2	1	0	10	2	6	1	5	26	0	19	2	16	14	2	58	162
	13-XII-68	Clear, warm	+	2	1	0	14	2	7	1	5	29	1	19	3	17	14	4	34	151
	14-XII-68	Clear, warm	+	2	1	0	10	3	6	2	5	27	1	19	1	16	14	5	33	143
		NOTE: Peak in autumn. Exceptional abundance of no one group; limited forest fauna.																		
TOTALS for Paraopeba and Curvelo areas, 14 collecting days				2	4	27	3	21	4	7	60	1	30	4	40	25	7	120*	355	
Parque do Gama, Distrito Federal Cerrado: Headwater forests, streams.	23-II-68	Clear-rainy, hot	++	2	2	2	22	2	9	0	4	23	0	11	2	25	19	1	63	175
	7-V-68	Clear, warm	+	1	1	2	17	1	10	1	6	29	1	11	2	23	16	0	47	167
	14-V-69	Clear, warm	+	4	2	3	22	1	12	1	8	42	1	53	3	47	16	0	63	274
	15-V-69	Clear, warm (includes afternoon in Brasília Country Club)	+	2	2	3	15	2	13	1	8	29	0	59	2	20	12	1	40	207
	17-V-69	Part cloudy, cool	+	2	2	5	21	2	13	1	8	37	0	41	3	44	16	0	76	269
	22-V-71	Clear, hot	+	1	1	3	15	1	10	0	6	26	0	46	2	23	11	0	61	205
	17-VI-72	Clear, hot	+++	2	2	2	20	1	8	1	6	42	1	81	2	54	18	1	66	305
	20-VI-72	Clear, warm	+++	2	1	1	17	2	12	2	7	43	1	84	2	49	17	0	59	297

TABLE 1. (*Continued*)

Locality	Date	Weather	Flowers	No. col.	Butterfly Groups MO	BR	SAT	DA	ITH	AC	HEL	NYM	LIB	THE	PL	RIO	PIE	PA	HESP	TOTAL
Jardim Zoológico, D.F.: Low humid forest, marsh, swamp.	24-II-68	Part cloudy, warm	++	2	2	0	9	3	15	0	6	22	1	7	2	9	14	0	36	126
NOTE: Peak in autumn. Abundance of Satyrinae, Nymphalinae, and Lycaenidae, especially *Thecla*.																				
TOTALS for Brasília area, 43 collecting days					4	13	45	3	22	6	13	95	1	130	4	130	27	12	250*	755
São Vicente, Mato Grosso: Heavy forest.	28-V-69	Clear, hot	++	2	1	0	21	2	6	1	8	39	0	14	2	29	11	1	51	186
Buriti, Chapada de	22-XII-68	Part cloudy, hot	+	2	2	1	24	0	10	1	3	33	0	17	1	28	13	4	42	179
Guimarães, Mato	28-XII-68	Part cloudy, hot	+	1	2	1	24	0	10	1	4	39	0	10	0	30	10	3	56	190
Grosso: Heavy	2-I-69	Cloudy, rainy	+	1	2	1	32	1	8	1	6	26	0	16	2	27	12	3	57	194
and sparse	4-I-69	Clear, cool	+	1	2	4	35	0	11	1	5	44	1	17	1	27	15	4	53	220
moist woods,	23-V-69	Clear, hot	+	2	2	3	25	1	12	2	8	44	0	14	2	42	12	3	47	217
dry woods,	24-V-69	Clear, hot	+	2	2	3	32	2	13	3	9	58	1	11	2	35	13	3	54	241
marshes.	25-V-69	Clear, hot	+	2	2	1	22	2	10	2	11	55	1	21	2	32	15	4	79	259
	26-V-69	Clear, hot	+	KB: 2	2	5	38	2	12	3	10	61	1	14	2	46	14	4	93	307
				KB+SN: 2	2	5	38	2	13	3	10	64	1	25	2	54	15	5	122	361
	27-V-69	Clear, warm	+	2	2	2	29	1	12	2	9	55	0	10	2	57	12	5	76	274
	31-V-71	Cloudy, rainy	+	1	2	1	24	2	12	3	8	48	0	4	2	36	14	3	71	230
	4-VI-71	Clear, warm	+	1	2	3	33	2	12	3	10	45	0	8	2	43	13	4	93	273
	5-VI-70	Part cloudy, hot	+	1	2	2	25	2	14	2	10	54	0	4	2	26	11	1	57	212
	9-VI-70	Part cloudy, hot	+	1	2	3	36	2	13	3	10	61	1	14	2	40	15	6	84	292
	15-VI-70	Clear, hot	+	1	2	3	36	3	14	3	9	58	1	5	2	42	17	7	100	302
	26-VI-72	Clear, hot	±	2	1	2	38	2	16	1	9	57	0	16	2	42	14	3	72	275
NOTE: Peak in late autumn. Abundance of Satyrinae and Nymphalinae. Reduced no. of rare species.																				
TOTALS for Buriti area, 44 collecting days					2	9	45	4	25	3	14	86	1	50	2	80	20	22	170*	533
Trail from Salto do Céu to Rio	1-VII-72	Clear, hot	+++	2	1	3	42	1	13	0	11	75	1	14	1	41	14	5	75	297
Vermelho, W. Mato	2-VII-72	Clear, hot	+++	2	1	4	41	1	12	0	13	87	1	9	1	30	15	7	87	309
Grosso: Highland	3-VII-72	Clear, hot	+++	2	1	3	47	1	12	0	11	86	1	11	2	33	13	6	84	311
Amagonian-type heavy forest	NOTE: Exceptional abundance of Satyrinae and Nymphalinae, scarcity of Theclinae.																			
Riozinho, Rondonia: Heavy moist forest	7-VII-72	Clear to rainy	++	3	2	1	29	1	19	1	17	27	0	9	0	36	9	4	61	216
REGIONAL TOTALS over many years' collecting (First three lists taken from Ebert, 1970)																				
Eastern Pernambuco—Lowland tropical forest (HE)					3	7	23	3	15	2	12	65	1	98	3	76	27	3	194	532
Eastern São Paulo—Lowland and mountain forest (E)					7	19	46	5	32	8	14	105	1	88	3	93	44	21	273	759
Rio de Janeiro and vicinity (low & mt. forest) (HE)					6	19	39	4	26	5	15	90	1	117	3	77	38	19	283	742
Rio de Janeiro and vicinity (author's totals)					8	20	43	4	38	8	16	115	1	150*	3	115	44	33	350*	948
Cerrado portion of Planalto (excl. blend zones)					4	17	75	4	29	7	13	117	1	150*	4	157	30	24	350*	982
Median-littoral humid forest (Bahia, Esp. Santo)					8	22	70	4	46	7	17	100	1	100*	3	100*	44	18	250*	790
TOTALS FOR EXTRA-AMAZONIAN BRAZIL					8	37	150*	5	75	15	21	200	1	350*	5	350*	60	57	800*	2134*

Regional and Seasonal Comparisons by Subgroup (Table 1)

It is of interest to note here the seasons and areas in Brazil, and in other regions in the Neotropics, where, in our experience and based upon these methods of intensive collecting, there may be expected maximum numbers of species in each of the major groups of diurnal Lepidoptera.

Morphos in southern Brazil are most common in Santa Teresa, Espírito Santo; all eight species which we recognize in the extra-Amazonian area may be found flying together there in April. Very few other such small areas harbor over six species, and in more subtropical climates these rarely overlap during their single yearly broods in summer. If the same criteria of conspecificity are applied in other regions, eight species may also be captured (though possibly not all at the same season) in some areas of the eastern slopes of the Andes in Peru; and seven species may be found flying together at one time in many warmer parts of tropical America, where most species are multibrooded.

Satyrines (including brassolines) seem to be most diversified in areas of alternating dry scrubby woodland and moist riparian forest, with a strong additional element of open grassland and marsh, such as the Chapada de Guimarães and Brasília areas, with 54 and 58 species known to date. Some larger areas have the required diversity to harbor nearly 100 species in this subfamily. A few areas in the Andes may surpass 100 species, though it seems unlikely that more than fifty could be captured in a day. The **brassolines** alone seem most common in hilly areas where neighboring faunal regions meet; the key to their observation and collection is always the discovery of their preferred afternoon and evening flyways and the liberal use of traps with preferred local bait. The area of Santa Teresa has at least twenty species, of which ten have been observed in a single day; we know of no other area in the Neotropics with a similar species abundance. While satyrines and brassolines in general show less strict seasonal variation than other nymphalid groups, individual species often show marked alternations of heavy broods and essentially complete absences. A few temperate-zone species are single- or double-brooded, in summer only.

In Brazil, the maximum number of species of **Ithomiinae** is reached in the median-littoral region, a broad area of moist coastal tablelands in southern Bahia and northern Espírito Santo which shelters many endemic species. Here, 30 species can be found in a single "pocket" in winter, and 25 to 27 can reasonably be collected in a single day. These numbers do not compare with those found in the upper Amazonian and Orinocan tributaries on the slopes of the Andes in Bolívia, Peru, Ecuador, Colombia, and Venezuela, clearly the principal center of geohistorical evolution in

the subfamily. In the Chanchamayo valley (La Merced), Peru, and in north-central Venezuela, the author discovered nearly 50 species present, of which 40 could reasonably be captured in a single day, especially with the use of dried Heliotropium plant (Beebe, 1955; Masters, 1968) hung at favored locations within the "pockets." Collection of ithomiines is generally best in the dry season, though a few montane species are most common in the warmer, moist summer season. Many species in the family are notable for their accentuated and unpredictable variations in populations and abundance from season to season and year to year. The localized dry season "pockets," in which all of the species tend to fly together, are much diluted during the wet seasons, and occasionally switch their location dramatically from one year to the next.

The maximum number of species of **heliconians** found in one locality of extra-Amazonian Brazil is 17, in Santa Teresa; 16 of these have been observed in a single day. Again, this compares poorly with the numbers present in some parts of the Andean slopes of Ecuador and Colombia; on the Rio Negro in Meta, Colombia, over 30 species have been found, of which 22 were observed by the author in two days (Brown & Mielke, 1972). **Nymphalines**, many of them attracted to bait, have been found most commonly in extensive and very moist, slightly disturbed forests at the base of the mountains near Rio, and in the interior near Brasília, Buriti (Chapada de Guimarães), and Rio Vermelho (Amazon-type highland forest in western Mato Grosso), but the total lists for an area do not vary much from an average of 80 (locality) or 110 (larger region). The greatest abundance of **Nymphalidae**, broadly speaking, has been observed in Rio Vermelho (161 species in one day); however, if total numbers observed (as a smaller number per day) over a long period is considered, Santa Teresa, which blends four major faunal regions, is much richer.

Almost all tropical nymphalines, including heliconians and charaxines, are to be found most commonly in late summer and fall in cooler areas, and late winter in hotter regions. The genus *Eunica* contains many species that are practically limited to one brood in the late winter. A few larger species of Charaxinae are double- or triple-brooded only, showing much variation in abundance and freshness of individuals caught at different seasons.

For the extensive collection of **Theclinae**, no area can compare with the Brazilian cerrado in the early dry season. Although this habitat has much akin faunistically to an open forest, the trees rarely exceed 20 feet in height, and thus treetop-loving species can be netted easily, together with those preferring low flowers and grass. The spacing of the low trees assures abundant sun all day long, and the interspersal of occasional

denser growth (cerradão), more open areas (campo cerrado), and moist riverside and headwater woods guarantees the presence of a very wide variety of Theclas. The 47 species in this subfamily captured by the author and Karl Ebert in Itirapina, São Paulo, a southern outpost of the cerrado within the blend zone, in May 1967 (Ebert, 1970) represented an early and successful test of some of the methods described in this paper. In a good year (such as was 1972) in the Brasília area, a day's list of nearly 100 Theclas should be attainable by a party of three or four collectors; the maximum to date, with two persons, is 84, and a total lycaenid list of 137 species.

The only areas we have seen to match the forests of the Chapada de Guimarães for **Riodininae** are the lowland woods near Manaus, where 50 species were captured in two days in January 1970, and the swampy woods near Belém, where 45 species were found in two days in late December, 1970. Presumably, an area could be found in the lower middle Amazon which would produce nearly a hundred species of these brightly colored small butterflies in a day. Diversity of flora is a good clue to abundance of Riodininae, and favored male patrolways (hilltops and open moist woods are best) must be located, and hours of flight activity ascertained, to give good collecting.

In Brazil, **Papilionidae** are most abundant at the very beginning of the rainy season in September, especially in the upper Paraguay River basin, where over 20 species could be captured in a day; similar or greater numbers should be attainable in many areas of the upper Amazon basin, as well as in the foothills near Rio de Janeiro at this same season (24 species recorded in Xerém, not all on one day). The fall and winter are very poor in Papilionidae, except for occasional *Parides* in warmer areas.

Pieridae have been found most abundantly in the same areas and seasons as Papilionidae; the diversity is greatest in the foothills near Rio where mountain and lowland species mix (44 species recorded, 22 in a single day in Xerém). Outside Brazil, somewhat greater numbers may be encountered in favored seasons on the eastern slopes of the Andes.

Hesperiidae appear commonly in almost all Neotropical areas with diversified ecological biotopes (though much more rarely in extensive virgin forests); a daily list of over 100 species should be attainable in any of a number of regions in the good flower seasons. Table 1 shows an extraordinary correlation of numbers of skippers captured with flower abundance, which should be taken to heart by those who specialize in this family. Prominent in the flower groups that bring these butterflies out of the forest and concentrate them in accessible areas are members of the Eupatoriae, which flower principally in fall and winter in Brazil.

SUMMARY

A method for the conscious maximizing of selected daily butterfly lists in southern Brazil has permitted much new information to be obtained on the occurrence and biology of the small, localized, and/or high-flying species in the fauna, which tend to be least known. It also has provided a reasonably standardized basis for comparisons between different localities and seasons, both in overall number of species present and in relative abundance of the various subgroups of Rhopalocera. General conclusions on extensive, intensive, and seasonal frequencies closely match those presented by Ebert (1970), though the collecting methods used are fundamentally different.

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LITERATURE CITED

BEEBE, W. 1955. Two little-known selective insect attractants. Zoologica (New York) 40: 27–32.

BROWN, K. S., JR. 1970. The Heliconians of Brazil (Lepidoptera:Nymphalidae). Part I. Rediscovery of *Heliconius nattereri* in eastern Brazil. Entomol. News. 81: 129–140.

———. 1972. The Heliconians of Brazil (Lepidoptera:Nymphalidae). Part III. Ecology and biology of *Heliconius nattereri*, a key primitive species near to extinction, and comments on the evolutionary development of the species of *Heliconius* and *Eueides*. Zoologica (New York), in press.

BROWN, K. S., JR. & O. H. H. MIELKE. 1967. Lepidoptera of the Central Brazil Plateau. I. Preliminary list of Rhopalocera. J. Lepid. Soc. 21: 77–106, 145–168.

———. 1968. Lepidoptera of the Central Brazil Plateau. III. Partial list for the Belo Horizonte area, showing the character of the southeastern "blend zone." J. Lepid. Soc. 22: 147–157.

———. 1972. The Heliconians of Brazil (Lepidoptera: Nymphalidae). Part II. Introduction and general comments, with a supplementary revision of the tribe. Zoologica (New York) in press.

BROWN, K. S., JR. & R. FERREIRA D' ALMEIDA. 1970. The Ithomiinae of Brazil (Lepidoptera: Nymphalidae). II. A new genus and species of Ithomiinae, with comments on the tribe Dircennini d'Almeida. Trans. Amer. Entomol. Soc. 96: 1–17.

EBERT, H. 1970. On the frequency of butterflies in eastern Brazil, with a list of the butterfly fauna of Poços de Caldas, Minas Gerais. J. Lepid. Soc. 23: supplement 3, 1–47.

FOX, R. M., A. W. LINDSAY, H. K. CLENCH & L. D. MILLER. 1965. The Butterflies of Liberia. Mem. Amer. Entomol. Soc. 19: 1–438.

MASTERS, J. H. 1968. Collecting Ithomiidae with Heliotrope. J. Lepid. Soc. 22: 108–110.

MIELKE, O. H. H. 1967. Lepidópteros do Planalto Central Brasileiro. IV. Notas complementares sôbre os Hesperiidae da região e descrição de cinco espécies novas (Lepidoptera, Hesperiidae). Rev. Brasil. Biol. 27: 125–134.

———. 1968a. Lepidoptera of the Central Brazil Plateau. II. New genera, species and subspecies of Hesperiidae (Rhopalocera). J. Lepid. Soc. 22: 1–20.

———. 1968b. Lepidoptera do Planalto Central Brasileiro. V. Novas espécies de Hesperiidae e anotações sôbre outras espécies conhecidas. Rev. Brasil. Biol. 28: 447–455.

AN UNUSUAL MOTH IN CENTRAL ILLINOIS

After working on my car, at about 1400 on 14 November 1971, I drove it through a parking lot across the street from my home. I then noticed a large moth clinging to a building, about ten feet off the ground. A closer look revealed that it was a large noctuid. Immediately, I opened the back of the car, grabbed my net, made a lunge at the moth, and managed to capture it.

As soon as I got home, I checked my revised edition of Holland's *Moth Book*, and found that the moth I had just caught was *Thysania zenobia* Cramer. After reading that it was a "South American moth," I knew that I had caught something quite unusual for central Illinois. However, a moderately strong wind had been blowing from the south for several days preceding the capture, and as the specimen was slightly worn, this probably explains its presence this far north, especially at such a late time of year.

I am sure that this capture does not constitute a state record after checking with the University of Illinois and Eastern Illinois University; but it might be a new record at least for Coles County. If any members know of a previous capture of this species in this county, I would sincerely appreciate hearing from them.

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WING-SHAPE AND ADULT RESOURCES IN LYCAENIDS

Various small species of blues (Lycaenidae: Lycaeninae) are characterized by rather narrow elongated wings—a Nearctic example being *Zizula cyna* Edwards. In September of 1971 some observations were made on a related African species, *Zizula hylax* (F.) in the Gombe Reserve on Lake Tanganyika, Tanzania.