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SPRING MIGRATION STOPOVER BY CERULEAN WARBLERS IN NORTHERN MIDDLE AMERICA

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Resumen. – **El paso de la Reinita Cerúlea durante la migración de primavera en el norte de América Central.** – La Reinita Cerúlea (*Setophaga cerulea*) realiza una de las migraciones más largas entre los passeriformes pequeños, viajando aproximadamente 4.000 km entre las aéreas de anidación al este de Norte América y su residencia no-reproductiva al norte de Sur América. Sin embargo, a diferencia de otras aves migratorias, poco es conocido sobre este aspecto de la ecología de esta especie. Entre 2004 y 2009, equipos de biólogos residentes y extranjeros realizaron censos en 181 transectos lineales durante la última semana de marzo y las primeras tres semanas de abril en Belice, sur de México, Guatemala, Honduras y Nicaragua. En general, los resultados confirmaron la hipótesis de Ted Parker (1994) de que las Reinitas Cerúleas paran temprano en abril en las montañas bajas de la costa del Caribe al norte de América Central. Sin embargo, en contraste con las observaciones de Reinitas Cerúleas realizadas por Parker entre 600 y 750 m en Belice, en este proyecto las observaciones se distribuyeron uniformemente a estas elevaciones así como por encima y por debajo de este rango. Por otro lado, la frecuencia de observaciones de Reinitas Cerúleas fue mucho mayor en Belice, el sur de México y el centro de Guatemala que en cualquier otro lugar. Los números relativamente bajos de Reinitas Cerúleas encontrados durante la migración de primavera (134 individuos durante 701 h de investigación) ponen en duda la sugerencia de Parker de que la totalidad de la población de Reinitas Cerúleas se detiene en las montañas que miran hacia el Caribe del norte de América Central. Nosotros sugerimos otra hipótesis consistente con los resultados hasta la fecha; esta hipótesis propone que varias de estas aves vuelan directamente desde Sur América a Norte América en la primavera.

Abstract. – The Cerulean Warbler (*Setophaga cerulea*) has one of the longest migrations of any small passerine, traveling approximately 4,000 km between breeding grounds in eastern North America and non-breeding residency in northern South America. However, unlike many migratory birds, little is known about this aspect of the ecology of this species. In 2004 – 2009 teams of resident and foreign biologists conducted 181 line-transect surveys in Belize, southern Mexico, Guatemala, Honduras, and Nicaragua, during the last week in March and the first three weeks of April. Results generally confirm Parker's (1994) hypothesis that Cerulean Warblers stop in low mountains on the Caribbean coast of northern Central America in early April. However, in contrast to Parker's observations of Cerulean Warblers between 600 and 750 m in Belize, sightings in this project were evenly distributed at these and elevations above and below this range. The frequency of encountering Cerulean Warblers was higher in Belize, southern Mexico and central Guatemala than elsewhere. The relatively low numbers of Cerulean Warblers encountered during spring migration (134 individuals during 701 h of surveys) call into question Parker's suggestion that the entire population of Ceru-

lean Warblers stops over in the Caribbean-facing mountains of northern Middle America. We suggest a new hypothesis consistent with results to date, that many of these birds fly directly from South America to North America in the spring.

Key words: Cerulean Warbler, long-distance migration, migratory stopover, mixed-species flocks, northern Middle America, *Setophaga cerulea*.

INTRODUCTION

Migration may be the most difficult aspect to study in the life history of a Nearctic-Neotropical migrant bird because of the transitory nature of the phenomenon and the geographic complexity of the event. However, because this stage may occupy as much as one-third of a species' annual cycle (Mehlman *et al.* 2005, Newton 2006), explain as much as 85% of annual mortality (Sillett and Holmes 2002), and is subject to climatic variability to an increasing extent (Lehikoinen and Sparks 2010), identification (Moore *et al.* 2005, Holmes 2007) and preservation of stopover habitat is of the utmost importance (Gauthreaux 1999, Moore 2000, Mehlman *et al.* 2005), especially when developing a conservation strategy for a species of high conservation concern.

Cerulean Warbler (*Setophaga cerulea*) is such a species of high conservation concern (Rich *et al.* 2004, Birdlife International 2008) because of its long-term population decline as measured on the breeding grounds in eastern North America (Robbins *et al.* 1992, Veit *et al.* 2005, Sauer *et al.* 2011). Much of this decline has been attributed to the loss (Hamel 2000a), degradation, and fragmentation (Veit *et al.* 2005, Wood *et al.* 2006) of mature forest on both the breeding (Wood *et al.* 2005) and wintering grounds (Robbins *et al.* 1992, Parker 1994, Hamel 2000b).

This species also has one of the longest migrations of any warbler or passerine of similar size, traveling approximately 4,000 km between the breeding grounds in eastern North America and the wintering grounds in northern South America (Hamel 2000a, Hamel 200b). Unlike most migratory birds, however, remarkably few specimens or published observations exist for this species during spring and fall migration with the exception of those compiled by Ted Parker in the spring of 1992 in Belize (Parker 1994). Parker observed up to 100 individual Cerulean Warblers from 3 to 10 April 1992 in mature subtropical lower montane forests between 600 and 750 m elevation in the Columbia River Forest Reserve in the Maya Mountains of southern Belize (Fig. 1). He observed from one to six Cerulean Warblers foraging in individual mixed-species canopy flocks of native and migrant birds. Based on his observations, Parker proposed that during the first two weeks of April the species' entire population stops over in Caribbean-facing mountains of northern Middle America. Parker also proposed this stopover region extended from eastern Mexico, through southern Belize, across Guatemala and northern Honduras, and possibly northwestern Nicaragua.

We initiated a multiyear investigation of the occurrence of the Cerulean Warbler in northern Middle America during spring migration to answer these questions. Our specific objectives were: 1) to test Parker's predictions of Cerulean Warbler distribution and habitat use, 2) to evaluate the timing of migration during the assumed period of peak movement, 3) to estimate the elevational and geographic distribution of Cerulean Warblers migrating through northern Middle America, and 4) to describe the composition of mixed-species canopy flocks with which Cerulean Warblers were often associated.

METHODS

Study areas. Our study region included southern Belize, southeastern Mexico, central

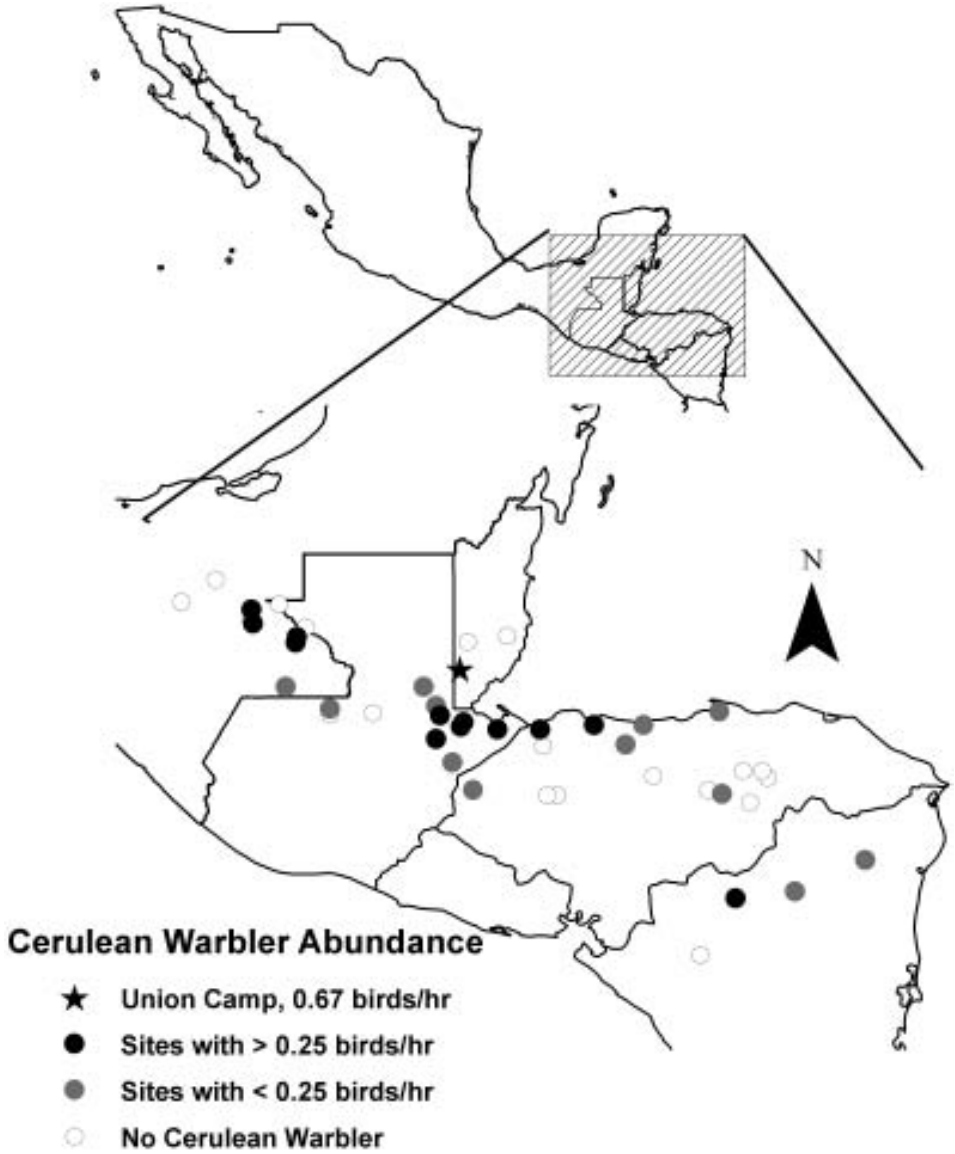

FIG. 1. Map of study areas in Middle America searched for Cerulean Warblers during spring migration 2004–2009.

Guatemala, northern Honduras, and western Nicaragua. As a first stage of this project, surveys were conducted in 2004 in the same location where Parker (1994) recorded his Cerulean Warbler observations at Union Camp, in the Columbia River Forest Reserve in southern Belize (16°23'55"N, 89°08'34"W, Fig. 1). Although Parker (1994) described the southern portion of that Belize site as having "particularly tall trees," we found severe but

localized damage to the forest canopy caused by Hurricane Iris in October 2001, and from a forest clearing made by a temporary illegal Guatemalan incursion.

In 2005–2009 some survey locations were chosen because they conformed to Parker's predictions that Cerulean Warblers were stopping in mature lower montane forests of Caribbean-facing mountains (Table 1). Other locations were specifically chosen because they differed from these conditions and were located in mature forests on non-Caribbean-facing slopes, at higher or lower elevations than those predicted by Parker (1994), or differed in both respects. Because of Cerulean Warbler occurrence in shade coffee plantations in South America (e.g., Jones *et al.* 2000, Bakermans *et al.* 2009, Colorado 2011), a set of surveys was completed in this habitat type, as well as locations of historic specimen collections in Mexico, Guatemala, and Honduras. A complete list of survey locations appears as an Appendix.

Field Surveys. We assessed Cerulean Warbler presence using transect survey records, and Cerulean Warbler relative abundance by calculating the encounter frequency of both Cerulean Warblers (number of Cerulean Warblers/hour of survey) and of flocks (number of flocks/hour of survey). Transect surveys were conducted usually along existing forest trails (Bibby *et al.* 2000). Surveys started within one half hour after dawn and occasionally in the late afternoon, with an average time of four hours per survey. Observers walked slowly (approximately 1km/hour) scanning mid-story, upper-story, and emergent trees for mixed-species flocks or single foraging birds. Survey dates were standardized each year to encompass the last week of March through the third week of April (comprehensive survey dates were 25 March to 22 April). Surveys were conducted by one to six teams of Mexican, Guatemalan, Honduran, Nicaraguan, and foreign biologists. Before each season a training session was given to team leaders and most assistants on survey methods and Cerulean Warbler identification.

During fieldwork conducted 2005–2007 we noted and identified to species all individuals in the mixed-species canopy flocks that we encountered. Incidental observations of Cerulean Warblers were also recorded. Playback songs of Cerulean Warbler or Lesser Greenlet (*Hylophilus decurtatus*), a common flock associate, were used for most flocks in 2005–2007 to enhance Cerulean Warbler detectability.

RESULTS

During 181 transect surveys conducted in spring 2004–2009 we recorded 134 Cerulean Warblers (98 males, 35 females, 1 unknown) in 69 of the 386 flocks recorded (Table 1). Eight incidental observations of Cerulean Warbler were also made during this period. One incidentally observed Cerulean Warbler was found away from any mixed-species foraging flock. Virtually all observations of Cerulean Warbler occurred in the canopy or upper mid-story of primary or mature secondary forests; four Cerulean Warblers were observed in the shade trees of rustic shade coffee plantations.

Nearly all Cerulean Warblers (132 of 134, 98%) were found on Caribbean-facing slopes ($\chi^2_{1\,df} = 25, P < 0.005$), although the encounter frequency of flocks was more equally divided between Caribbean and non-Caribbean facing slopes ($\chi^2_{1\,df} = 2.8, P > 0.1$). Distributions of both Cerulean Warblers ($\chi^2_{2\,df} = 0.4, P > 0.5$) and flocks ($\chi^2_{2\,df} = 0.8, P > 0.5$) in our three elevation categories were nearly identical to those expected based on the number of surveys conducted (Table 2). Cerulean Warbler encounter frequency was not uniform during the study period, with an apparent decrease after 13 April (93% of birds observed 2–14 April, median date 8 April; Fig. 2). The number of Cerulean Warblers detected in flocks ranged from one to five individuals (Fig 3).

Table 1. Cerulean Warbler survey totals in five countries in Middle America, 2004–2009

Country	N, surveys	N, survey locations	N, survey hours	N, Cerulean Warbler detections	N, flocks
Belize	9	3	31.50	16	n/a
Mexico	19	9	62.15	16	57
Guatemala	61	13	261.93	62	120
Honduras	79	16	301.99	31	198
Nicaragua	13	4	43.05	9	11
Total	181	45	700.62	134	386

Table 2. Surveys by geophysical location in five countries in Middle America, 2004–2009.

Survey location	N, surveys	N, survey h	N, Cerulean Warbler detections	N, flocks	Cerulean Warblers detected per survey h	Flocks encountered per survey h
Topographic position						
Caribbean facing	148	581.56	132	303	0.23	0.52
Not Caribbean facing	33	119.07	2	83	0.02	0.70
Elevation						
Below 500m	102	403.29	75	226	0.19	0.56
500m – 850m	46	159.24	32	93	0.20	0.58
Above 850m	33	138.10	27	67	0.20	0.49

Eighteen surveys, totalling 57 hours, were conducted in rustic shade coffee plantations, during which two Cerulean Warblers were recorded in 46 enumerated flocks (Cerulean Warbler encounter frequency of 0.04 birds/h). The 18 plantations were equally split between Caribbean and non-Caribbean facing slopes (1 Cerulean Warbler encountered in each). Most plantations (16) were at elevations similar or higher than the range predicted by Parker (1994); both Cerulean Warblers were observed at higher elevations. Five of the 18 rustic plantation sites were chosen only because they were in an area of historic Cerulean Warbler records, with one Cerulean Warbler being detected at one of these sites.

Five sites were surveyed because there was at least one historic Cerulean Warbler record for that site in Mexico (2 sites), Guatemala (1 site), and Honduras (2 sites; Table 3). Cerulean Warblers were encountered at three of these sites, where the original forest overstory remained intact. The habitat at two historic sites had been fragmented by human activities and no Cerulean Warblers were found there.

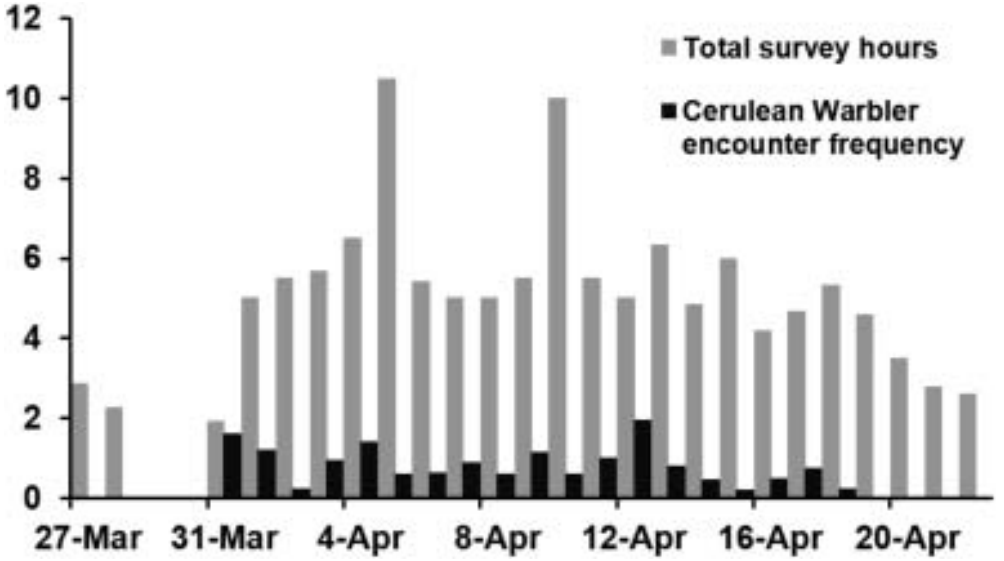

FIG. 2. Survey effort and encounter frequency of Cerulean Warblers per hour of survey effort by date during field surveys in Middle America in March-April 2004–2009.

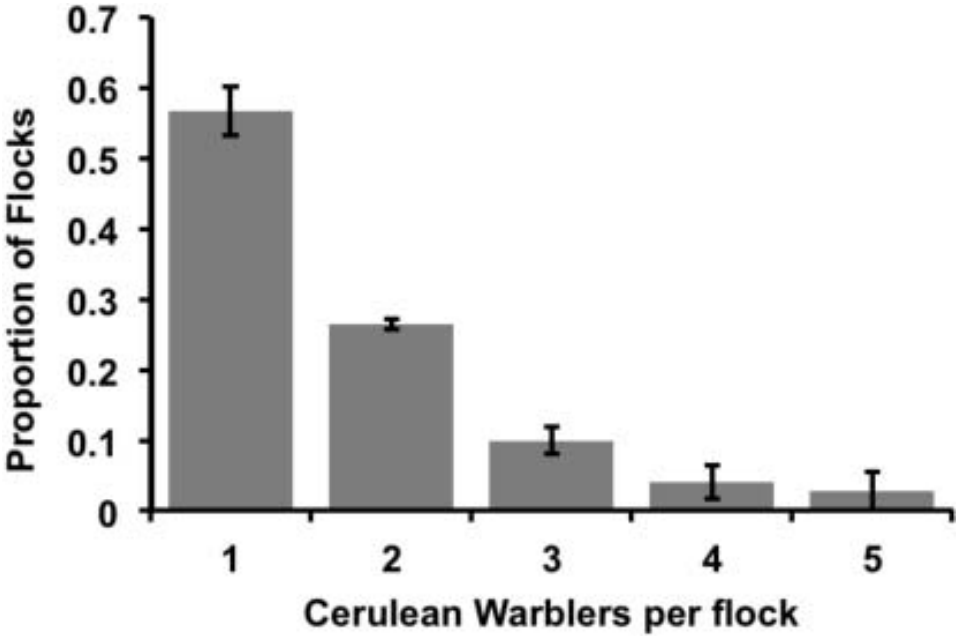

FIG. 3. Mean proportion of mixed-species foraging flocks observed in Middle America 2005–2007 containing different numbers of Cerulean Warblers, mean ± 1 SE of 67 completely enumerated flocks observed in each of the years: 2005, n = 12 flocks; 2006, n = 26 flocks; 2007, n = 29 flocks.

Table 3. Sites of historic Cerulean Warbler observations that were surveyed during the current study.

Country / Survey site	N, surveys	N, survey h	N, Cerulean Warbler detections	Current habitat condition
Mexico				
Bonampak Archeological site	2	8.58	3	intact
Palenque archeological site	2	4.05	0	fragmented
Guatemala				
San Gil Ecological Reserve	4	13.03	9	intact
Honduras				
Lago de Yojoa	6	22.33	0	fragmented
Lancetilla Botanical Garden and Research Center	1	4.00	1	intact

All Cerulean Warblers observed during formal surveys were found in mixed-species foraging flocks. In 68 flocks that contained at least one Cerulean Warbler we recorded 107 other avian species. An additional 65 species were encountered only in one or more of 236 fully enumerated flocks in which Cerulean Warbler was not recorded (Table 4). Thirty-two species occurred in at least 10% of the flocks. Among these were seven species that occurred in at least 20% of all flocks of either group. Rank order of species occurring in at least 10% of flocks was similar ($r_s = 0.79$, $N = 28$, $P < 0.0001$; Cerulean Warbler excluded from the comparison). Six of seven species found in more than 20% of the flocks, and 10 of 18 species recorded in at least 10% of flocks in both groups, were migratory species. Seven of these belonged to the family Parulidae. The most frequent species, occurring in 61% of all flocks enumerated, was Lesser Greenlet.

Playback response. Three team leaders used Cerulean Warbler song playback consistently during surveys in 2006 – 2007. Recordings of Cerulean Warbler or Lesser Greenlet were played to 31 flocks that contained at least one Cerulean Warbler. Fourteen males and one female from 10 flocks responded to the playback: 3 males and one female responded by coming closer to the speaker, 9 males vocalized by either chipping (2 males), singing one territorial song (1 male), or by singing whisper songs (Schafer 1917, Johnson & Kermott 1991; 6 males). Two males in one flock were already singing territorial songs before playback was used.

Replicate surveys. Twenty-three survey routes were surveyed more than once in Mexico (3 sites), Guatemala (4 sites), and Honduras (16 sites). Each such site was surveyed from two to four times between years or with a minimum of 3 days between surveys. At 17 (74%) of the sites the results of subsequent surveys were the same as the initial survey; either no Cerulean Warblers were encountered during any of the surveys (11 sites), or Cerulean Warblers were found during each survey (6 sites). At four sites Cerulean Warblers were recoded only on the first survey, and at two sites Cerulean Warblers were recorded only on the second survey.

Table 4. Species recorded in at least 10% of flocks enumerated in this study.

Common Name[1, 2]	*Scientific Name*		Flocks including Cerulean Warbler	Flocks without Cerulean Warbler	All Flocks
Plain Xenops	*Xenops minutus*		8	18	26
Olivaceous Woodcreeper	Sittasomus griseicapillus		7	14	21
Ivory-billed Woodcreeper	*Xiphorhynchus flavigaster*	B[3]	17	24	41
Mexican [Black-faced] Antthrush	*Formicarius analis (moniliger)*		7	8	15
Ochre-bellied Flycatcher	*Mionectes oleagineus*	B	10	26	36
Red-capped Manakin	*Pipra mentalis*		9	16	25
Yellow-throated Vireo*	*Vireo flavifrons*		8	9	17
Philadelphia Vireo*	*Vireo philadelphicus*		8	20	28
Red-eyed Vireo*	*Vireo olivaceus*	B	18	44	62
Tawny-crowned Greenlet	*Hylophilus ochraceiceps*	B	12	40	52
Lesser Greenlet	***Hylophilus decurtatus***	B	53	131	184
Green Shrike-Vireo	Vireolanius pulchellus		8	21	29
White-breasted Wood-Wren	*Henicorhina leucosticta*		9	18	27
Wood Thrush*	*Hylocichla mustelina*		7	12	19
Worm-eating Warbler*	*Helmitheros vermivorum*		10	22	32
Golden-winged Warbler*	*Vermivora chrysoptera*		21	22	43
Black-and-white Warbler*	***Mniotilta varia***	B	37	83	120
Tennessee Warbler*	***Oreothlypis peregrina***	B	22	78	100
American Redstart*	***Setophaga ruticilla***	B	28	69	97
Cerulean Warbler*	*Setophaga cerulea*		68	0	68
Magnolia Warbler*	***Setophaga magnolia***	B	27	88	115
Blackburnian Warbler*	Setophaga fusca		18	23	41
Chestnut-sided Warbler*	***Setophaga pensylvanica***	B	32	84	116
Black-throated Green* Warbler	***Setophaga virens***	B	19	48	67
Golden-crowned Warbler	*Basileuterus culicivorus*	B	11	30	41
Wilson's Warbler*	*Cardellina pusilla*	B	14	31	45

Table 4. Continued.

Common Name[1, 2]	*Scientific Name*		Flocks including Cerulean Warbler	Flocks without Cerulean Warbler	All Flocks
Red-crowned Ant-Tanager	*Habia rubica*		10	17	27
Summer Tanager*	*Piranga rubra*	B	12	48	60
Red-legged Honeycreeper	*Cyanerpes cyaneus*	B	7	30	37
Black-faced Grosbeak	*Caryothraustes poliogaster*	B	12	32	44
Baltimore Oriole*	*Icterus galbula*	B	8	27	35
Olive-backed Euphonia	Euphonia gouldi	B	8	26	34
	Number of Flocks		68	236	304
	Total Species		108	164	173
	Total Species Registrations		722	1795	2517
	Species in >10% of flocks		32	18	22
	Registrations of Species in >10% of flocks		545	939	1470
	Proportion of registrations in species in >10% of flocks		0.75	0.52	0.58
	Species in >20% of flocks		12	8	9
	Registrations of Species in >20% of flocks		360	629	929
	Proportion of registrations in species in >20% of flocks		0.50	0.35	0.37

[1]Species marked in bold occurred in more than 20% of flocks of both subsamples.
[2]Asterisks indicate migratory species.
[3]Species marked "B" were encountered in more than 10% of flocks in both subsamples.

DISCUSSION

The initial goal of this project was to determine whether large numbers of Cerulean Warblers continue to use the same location in the Columbia River Forest in southern Belize where Parker (1994) made his original observations in 1992. Based on a field visit to the site in 2004, we have established that they do. In fact, Cerulean Warblers were the most common Neotropical migrant encountered during the three and a half days of surveys around Union Camp in the Columbia River Forest from 2–5 April 2004.

Other major goals of the project were to assess the extent of the geographic area over

which Cerulean Warblers occur during spring migration, to determine the characteristics of the habitat they utilize, and to determine the timing of migration stopover in Middle America. Parker (1994) hypothesized that during spring migration Cerulean Warblers are found in "suitable lower montane forest facing the Caribbean coast". Our results generally concur with the second part of the hypothesized distribution in the forest on Caribbean-facing slopes. However, we encountered Cerulean Warblers at nearly the same frequency at all elevations surveyed. We believe that this finding calls into question the first part of the hypothesis, and suggests that the birds probably make landfall over a broad range of elevations.

Another interesting contrast to Parker's hypothesis that the spring stopover region extends from eastern Mexico, through southern Belize, across Guatemala and northern Honduras, and possibly into northwestern Nicaragua is that the birds we encountered were not equally distributed within this region. Although we did find Cerulean Warblers on the Caribbean facing slopes throughout this area, the frequency of encountering Cerulean Warblers was much higher in southern Mexico, southern Belize, central Guatemala, and northwestern Honduras, suggesting that there may be a higher density of Cerulean Warblers in the narrow arc within this region.

Shade coffee plantations are an important habitat type for Cerulean Warblers during the non-breeding season in northern South America (Bakermans *et al.* 2009, Sanchez-Clavijo *et al.* 2009, Colorado *et al.* 2012). Although rustic shade plantations were actively sought for survey locations during this study, few Cerulean Warblers were found in this habitat type. We are unable to assess from available data whether this habitat is important to Cerulean Warblers during spring migration, and recommend further studies to address this question.

The timing of our observations confirms Parker's findings and the suggestions of Hamel (2000a) that the spring migration period in Middle America is a short one. Most of the Cerulean Warblers observed in this study were found in the first two weeks of April; however, insufficient surveys were conducted in March and late April to more fully complete our understanding of the timing of Cerulean Warbler spring migration in the region.

The similarity of the composition of flocks in which Cerulean Warblers were and were not recorded suggests that these warblers were not selecting flocks based upon composition. Rather it appears that they were selecting flocks based upon availability. The large number of enumerated flocks in which Cerulean Warblers were not found indicates that substantial capacity exists for the birds to join additional flocks during migration. Why the warblers were not found in more flocks is an open question.

On the basis of its frequency and abundance in flocks, Lesser Greenlet is likely a nuclear species of canopy flocks in northern Middle America (Botero 2002, Srinivasan *et al.* 2010). Although the use of playback of Lesser Greenlet vocalizations likely affected the detection rate of this species, previous studies (Robinson *et al.* 2000, Anderson & Naka 2011) have also shown that Lesser Greenlet is numerically dominant in upper strata of moist forests of Middle America, including at sites used in the present study. The high frequency of migratory species in these flocks suggests that mixed-species flocks in Middle American forests are particularly important for migratory birds, perhaps especially warblers, during passage. The 11 migratory warbler species found in at least 10% of all flocks accounted for 33% of all species identifications in the 701 hours of fieldwork.

Although our results affirm that northern Middle America is a stopover area for migrating Cerulean Warblers in the spring,

the relatively low numbers of Cerulean Warblers encountered (134 individuals during 701 hours of surveys) calls into question the suggestion (Parker 1994) that the entire population is stopping in this small geographic area to replenish fat reserves consumed in their flight across the western Caribbean Ocean and before crossing the Gulf of Mexico. In addition, relatively few springtime observations exist of Cerulean Warblers along the coast of northern South America (GC pers. obs.; N. Bayly pers. com.) or along the Gulf Coast of the United States (http://ebird.org/content/ebird/about/occurrence-maps/cerulean-warbler [accessed 2/2012]). Given that the southerly winds aloft in early spring are favorable for migratory movements from South to North America (Gauthreaux *et al.* 2005), the physical proportion of Cerulean Warblers favorable to long-distance flight (Averill 1920), and the flight ranges predicted for other small songbirds (Nisbet *et al.* 1963, Bayly & Gomez 2011), we hypothesize that Cerulean Warblers, especially in the eastern portion of the non-breeding range, fly directly from highland wintering grounds in northern South America to the highland breeding grounds in the southeastern United States or into the riverine forests along the Mississippi corridor. We further speculate that the birds wintering in the western portion of the non-breeding range move northward and eastward along the northern Andes and then fly directly to North America.

One alternative hypothesis to explain the occurrence of Cerulean Warblers in spring in northern Middle America is that these birds have encountered weather or other difficulties that do not allow them to make the direct over-water flight. A reverse pattern may exist in the fall when Cerulean Warblers are regularly found in a relatively small region of Caribbean-facing slopes in Costa Rica (E. Carman pers. com.). A second hypothesis is that the birds are following multiple pathways during spring migration, as is the case for Swainson's Warbler (*Catharus ustulatus*; Ruegg *et al.* 2006). Tankersley & Orvis (2003) offer additional insight into this possibility.

Regardless of the origin or proportion of the global population of Cerulean Warblers stopping over in northern Middle America, this area is of critical importance to a substantial segment of this population. Thus, we believe it is important not only to identify the extent of this stopover range, but also to integrate conservation of Cerulean Warbler and other migratory species into the management and protection status of these lands. Indeed, the list of species found in more than 10% of Middle American flocks surveyed during the spring migration period is a good basis for use in training observers in identification of flock members. Consequently we recommend that the next phase of spring migration study should be the development and field-validation of a predictive habitat model for Cerulean Warbler during spring migration in Middle America (see, e.g., Barker *et al.* 2006, Buehler *et al.* 2006). Implementing conservation management objectives into the land use activities of the inhabitants of lands identified as important by the model, using methods similar to those of Fundación ProAves *et al.* (2010), Skolnik *et al.*, (2012), or Santander *et al.* (2012), will be a distinct positive step in an action plan to protect valuable stopover habitat from loss or degradation.

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Appendix. Sites in northern Middle America surveyed for Cerulean Warblers 2004–2009. Asterisks indicate sites of historic Cerulean Warbler observations. Elevations are averages of locations surveyed within the indicated sites. Values in **bold** lettering indicate the summary of effort and composite avian measures for the indicated country.

					Field Effort		Birds Observed	
Country and Survey Site*	Latitude	Longitude	Elevation, m a.s.l.	Caribbean-facing?	N, Surveys	N, Survey h	Mixed-species Flocks per Survey h	Cerulean Warblers per Survey h
Belize								
Columbia River Forest Reserve*	16°24'N	89°08'W	730	yes	7	24	n/a	0.67
Chiquibul Nat. Park/Las Cuevas	16°44'N	88°00'W	550	no	1	4	n/a	0
Cockscomb Basin Wildlife Sanctuary	16°48'N	88°30'W	425	yes	1	3.5	n/a	0
Total Belize, N = 3 Locations					9	31.5	n/a	0.5
Mexico								
Bonampak Archeological Site*	16°43'N	91°04'W	310	yes	2	8.58	1.4	0.35
MABR, Canon del Colorado	16°11'N	91°11'W	190	yes	3	9.82	0.71	0.1
Metzabok Protected Area	17°07'N	91°36'W	590	yes	4	14.67	0.82	0.41
Naha Protected Area	16°57'N	91°35'W	950	yes	2	7.59	0.53	0.53
Palenque archeological site*	17°29'N	92°02'W	125	no	2	4.05	1.48	0
Petalcingo	17°13'N	92°27'W	1050	no	2	3.32	0.9	0
Sierra de Cojolita Reserve	16°47'N	91°03'W	350	yes	1	3.67	0.82	0.54
Yaxchilán Archeological site	16°54'N	90°57'W	110	yes	1	4.67	1.07	0
Zaragosa	17°00'N	91°37'W	1025	yes	2	5.78	0.87	0
Total Mexico, N = 9 Locations					19	62.15	0.92	0.26
Guatemala								
Aldea Nueva Las Tortugas	15°50'N	89°19'W	205	yes	7	31.19	0.48	0.45
Brecha	15°51'N	90°39'W	235	yes	4	19.87	0.4	0
Aldea Cecobuc	15°57'N	89°22'W	270	yes	7	28.5	0.28	0.11

Appendix. Continued.

Country and Survey Site*	Latitude	Longitude	Elevation, m a.s.l.	Caribbean-facing?	Field Effort: N, Surveys	Field Effort: N, Survey h	Birds Observed: Mixed-species Flocks per Survey h	Birds Observed: Cerulean Warblers per Survey h
Guatemala								
CNNP, Sierra Santa Cruz East	15°42'N	89°04'W	265	yes	5	23.58	0.38	0.47
CNNP, Sierra Santa Cruz, North	15°45'N	89°02'W	130	yes	2	10.25	0.59	0.39
CNNP, Sierra Santa Cruz, South	15°33'N	89°22'W	675	yes	6	28.59	0.45	0.38
Laguna Lachuá Nat'l Park	15°55'N	90°39'W	190	yes	6	24.09	0.33	0.21
Mucbilhá	15°52'N	90°08'W	210	yes	3	10.92	0.37	0
San Gil Ecological Reserve*	15°40'N	88°37'W	300	yes	4	13.03	1.07	0.69
Sierra de las Minas Biosphere Reserve	15°16'N	89°10'W	650	yes	4	22.17	0.45	0.18
SLNP, El Porvenir	17°11'N	91°16'W	145	yes	5	19.42	0.36	0
Western Maya Mountains	16°11'N	89°31'W	400	no	7	25.5	0.63	0.04
Yaxchilán archeological site	16°54'N	90°57'W	150	yes	1	4.83	0.41	0
Total Guatemala, N = 13 Locations					61	261.93	0.46	0.24
Honduras								
Capiro Calentura Nat'l Park	15°53'N	85°56'W	550	mixed	9	31.42	0.83	0.06
Catacamas	14°53'N	85°54'W	1210	no	2	9.8	0.51	0.1
Cerro Azul Meambar Nat'l Park	14°52'N	87°54'W	850	yes	4	18.33	0.55	0
Corozal-Las Flores	14°47'N	85°34'W	415	no	1	4.25	0.71	0
Culuco / La Llorona	15°05'N	85°21'W	600	yes	7	19.11	0.42	0
Gualaco	14°56'N	86°04'W	1060	no	1	2.77	0.72	0
La Union	15°06'N	86°44'W	1060	no	1	2.62	0	0
Lago de Yojoa*	14°52'N	88°01'W	680	no	6	22.33	1.43	0

Appendix. Continued.

Country and Survey Site*	Latitude	Longitude	Elevation, m a.s.l.	Caribbean-facing?	Field Effort		Birds Observed	
					N, Surveys	N, Survey h	Mixed-species Flocks per Survey h	Cerulean Warblers per Survey h
Honduras								
Lancetilla Botanical Garden and Research Center*	15°43'N	87°27'W	40	yes	1	4	0.75	0.25
North of Copán	14°56'N	88°55'W	1050	yes	1	10.5	0.67	0.1
Pico Bonito Nat'l Park North	15°43'N	86°51'W	350	yes	23	90.91	0.64	0.2
Pico Bonito Nat'l Park South	15°29'N	87°04'W	590	yes	5	19.5	0.46	0.05
Pisijire	15°10'N	85°25'W	550	yes	2	4.45	0.67	0
Sierra de Agalta Nat'l Park	15°10'N	85°39'W	1070	no	5	22.25	0.31	0
Sierra de Merendón	15°28'N	88°04'W	770	yes	4	14.5	0.55	0
Sierra de Omoa	15°40'N	88°06'W	500	yes	7	25.25	0.67	0.28
Total Honduras, N = 16 Locations					79	301.99	0.66	0.1
Nicaragua								
Bosawás BR, NP Saslaya	13°42'N	85°01'W	650	yes	8	23.84	0.34	0.13
Western Bosawás Bioreserve	13°37'N	85°44'W	1110	yes	1	6.33	n/a	0.79
Cola Blanca National Reserve	14°05'N	84°10'W	390	yes	3	9.75	0.31	0.1
San Ramón	12°56'N	86°10'W	1080	no	1	3.13	n/a	0
Total Nicaragua, N = 4 Locations					13	43.05	n/a	0.21
Grand Total, N = 45 Locations					181	700.62	n/a	0.19