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MIGRATION OF *EMPIDONAX* FLYCATCHERS THROUGH NORTHEAST BELIZE

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Resumen. – Migración de atrapamoscas del género *Empidonax* en el noreste de Belize. – Estudiamos la ocurrencia y el comportamiento de parada de especies de atrapamoscas del género *Empidonax* durante la migración de otoño y de primavera en el noreste de Belize. Registramos 173 individuos de cinco especies durante migración de otoño y solo uno durante primavera. Esto sugiere que las rutas migratorias de primavera, para la mayoría de especies, no pasan por el noreste de Belize. Basados en estimados globales de población, las frecuencias de captura obtenidas fueron mayores a las esperadas para *Empidonax traillii* y *E. virescens* en el otoño, mientras que las de *E. flaviventris*, *E. alnorum* y *E. minimus* fueron menores. Estos hallazgos, combinados con fuentes secundarias de información, indican que las primeras dos especies tienen afinidad por una ruta trans-Golfo hasta la península de Yucatán en el otoño mientras que las tres especies restantes adoptan una ruta vía México circundando el Golfo. La evidencia limitada de aves recapturadas sugiere que *E. traillii* y posiblemente *E. alnorum* reabastecieron sus reservas energéticas en nuestra área de estudio.

Abstract. – We studied species occurrence and stopover behavior in *Empidonax* flycatchers during fall and spring migration in northeast Belize. We recorded 173 individuals of five species of *Empidonax* flycatcher during fall migration but just one individual during spring migration, suggesting that spring migration routes for the majority of species do not pass through northeast Belize. Based on expected frequencies from global population estimates, Willow Flycatcher and Acadian Flycatcher were captured with a greater frequency than expected during fall migration, while Yellow-bellied Flycatcher, Alder Flycatcher and Least Flycatcher were rarer than expected. These findings, in combination with secondary sources of information, indicate that the former two species have an affinity for a trans-Gulf migration route to the Yucatán peninsula during the fall, while the latter three species generally adopt a circum-Gulf route via Mexico. Limited evidence from recaptured birds suggests that Willow and possibly Alder Flycatcher replenished their energy reserves in our study area. *Accepted 17 May 2011.*

Key words: Belize, Central America, *Empidonax* flycatchers, migration routes, stopover behavior.

INTRODUCTION

Empidonax flycatchers are difficult to identify, with individuals of some species remaining inseparable even after in-hand examination (Pyle 1997). As a result, information about their migratory routes and stopover sites is limited, particularly in the Neotropics, and the tools necessary to develop conservation measures for species of this genus during migration are lacking (Petit 2000, Faaborg *et al.* 2010).

Eleven species of *Empidonax* flycatchers that breed in North America spend the non-breeding season either in Mexico or Central and South America (Poole 2011). For most species, there is some information about their migratory movements within North America

(Sealy & Bearman 1987, Hussell 1991a & b), however, the routes they take, the duration and location of their stopovers and, in some cases, even their wintering destinations in the Neotropics, are poorly known (Hutto 2000, Nishida & Whitfield 2005). Aside a few published accounts from Mexico and South America (Ruelas *et al.* 2005, Nishida & Whitfield 2005, Martínez-Leyva *et al.* 2009, Colorado 2010), we know of no focused studies that contribute to our knowledge of migratory routes in *Empidonax* Flycatchers once they leave North America.

Belize lies at the base of the Yucatán Peninsula and on a major flyway used by Neotropical migrants on their way to and from nonbreeding grounds in the Neotropics (Johnson & Winker 2008, Bayly & Gómez 2011). We studied the patterns of occurrence of *Empidonax* flycatchers during the course of one year in northeast Belize. Five species have been recorded in Belize of which Least (*Empidonax minimus*) and Yellow-bellied Flycatchers (*E. flaviventris*) are considered wintering species, while Acadian (*E. virescens*), Alder (*E. alnorum*) and Willow Flycatchers (*E. traillii*), have only been recorded as transients during migration (Jones 2005). We hypothesized that these five species of *Empidonax* flycatchers would migrate through northeast Belize during fall and spring, using a route that takes them across the Gulf of Mexico in both journeys. Additionally, we use data on body condition in recaptured birds to infer if *Empidonax* flycatchers were replenishing their energy reserves in northeast Belize during migration.

METHODS

We worked in the Corozal District, northeast Belize, on the southeastern portion of the Yucatán peninsula, approximately 2.5 km south of Sarteneja village (18º20'06"N, 88º07'29"W, sea level). Detailed descriptions of the study site and habitats sampled can be found in Gómez-Montes & Bayly (2010) and Bayly & Gómez (2011). We set up a banding station with 20 mist nets within an area 1 km in diameter supporting a matrix of forested and mangrove scrub habitats. Mist nets were either 12 m or 18 m long, 2.5 m high and with mesh size 32 mm or 36 mm. All mist netting took place between 2 September and 10 November 2007 (fall migration) and 17 March and 14 May 2008 (spring migration). Mist nets were operated daily for 3.5 hours after first light. In fall, mean daily mist net effort ± SD (n = 60 days) was 54.3 ± 18.1 hours (1 net hour = one 12 m net open for one hour), for a total of 3260 net hours. In spring, mean daily net effort ± SD (n = 59 days) was 79.3 ± 24.1 hours, totaling 4680 net hours.

Mist nets were checked at regular intervals (max 40 min) and birds were extracted and returned to a banding station. *Empidonax* flycatchers were identified using the combination of measurements suggested in Pyle (1997). After initial measurements, if birds fell into the "Traill's flycatcher" complex (Pyle 1997), which includes Willow and Alder flycatchers, we continued the identification process using both a scatter graph of bill length versus Formula I = (longest p – p6) – (p5 – p10) (Hussell 1990), and Formula R = ((longest p – p6) + (p9 – p5) + (wg – tl)) ÷ ((p6 – p10) + bill from nares)) (Pyle 1997). Individuals of these two species that could not be separated with 95% confidence, using the above formulas, were left as the categorical Traill's flycatcher group.

After identification, *Empidonax* flycatchers were fitted with a uniquely numbered Porzana metal band and the following data were taken prior to release: Age - following Pyle (1997); Fat Score - nine point scale following Redfern & Clark (2001); Muscle Score - four point scale following Redfern & Clark (2001); and Body Mass - measured to the nearest 0.1 g using an electronic balance.

To determine whether differences in the number of individuals captured between species reflected differences in migratory route choice or if they were a result of differences in relative global abundance, we calculated expected frequencies of *Empidonax* flycatchers based on population estimates given in Rich *et al.* (2004) and compared them to observed frequencies using a Chi-squared test. Assuming that all species have the same probability of migrating through our study region, then differences between observed and expected capture totals will indicate either an affinity for this migration route or the use of an alternative one. The reliability of this analysis is dependant on two assumptions. Firstly that when present in equal numbers each species of *Empidonax* flycatcher has an equal probability of capture and secondly that all species use the habitats sampled in this study. With regards to the first assumption, *Empidonax* flycatchers have similar foraging strategies (Poole 2011) and therefore probability of capture is unlikely to result in large differences in capture totals. Concerning the second assumption, we sampled the two most commonly occurring habitats at the landscape level in northeast Belize within a 10 km radius of our study site. Beyond this area, Bayly & Gómez (2011) surveyed the third dominant habitat type in the study region through transect surveys and found no evidence of a difference in species composition. Although we cannot rule out an effect of habitat use on capture totals, we believe that it is unlikely to have led to large differences in relative abundance between species.

In addition to presenting data from mist-netting in Belize, we utilize probability of occurrence data from North America and Central America downloaded from eBird to support our findings (Cornell Lab of Ornithology & National Audubon Society 2011). These maps should be evaluated cautiously given that eBird data are not collected systematically, and that *Empidonax* flycatchers are difficult to identify in the field. However, eBird records are a good reference tool to hemisphere wide movements of migrants.

RESULTS

We captured 174 individuals of the five species of *Empidonax* flycatchers expected to occur in northeast Belize. All birds were captured during fall migration, except for one Least Flycatcher captured during spring migration. 70% of fall captures occurred between 19 September and 6 October 2007 and were dominated by Alder and Willow Flycatchers (Fig. 1). Willow Flycatcher was the most abundant species with 70 captures, followed by Alder Flycatcher with 36 captures (Table 1). In addition, 43 individuals in the Traill's flycatcher complex could not be separated between Alder or Willow. Acadian, Least, and Yellow-bellied Flycatchers made up just 14% of the total captures. The relative abundance of all species during fall migration was significantly different from their expected abundance ($\chi^2 = 811.3$, $P < 0.001$) based on population estimates given in Rich *et al.* (2004). Acadian and especially Willow Flycatcher were commoner than expected while Alder, Yellow-bellied and Least Flycatcher were rarer than expected (Table 1).

Most individuals of transient species were carrying limited fat reserves on first capture during fall migration. Median muscle scores were of 1 and 2 and median fat scores of 0 and 2 (Table 2). Recapture rates were low at our study site, giving rise to three recaptures of Willow Flycatcher and three of individuals from the Traill's Flycatcher complex. All recaptured individuals showed increases in body mass such that mean daily rate of increase was 0.13 g/day or 2.6% of lean body mass per day. Acadian Flycatchers carried larger fat deposits than the other two transient

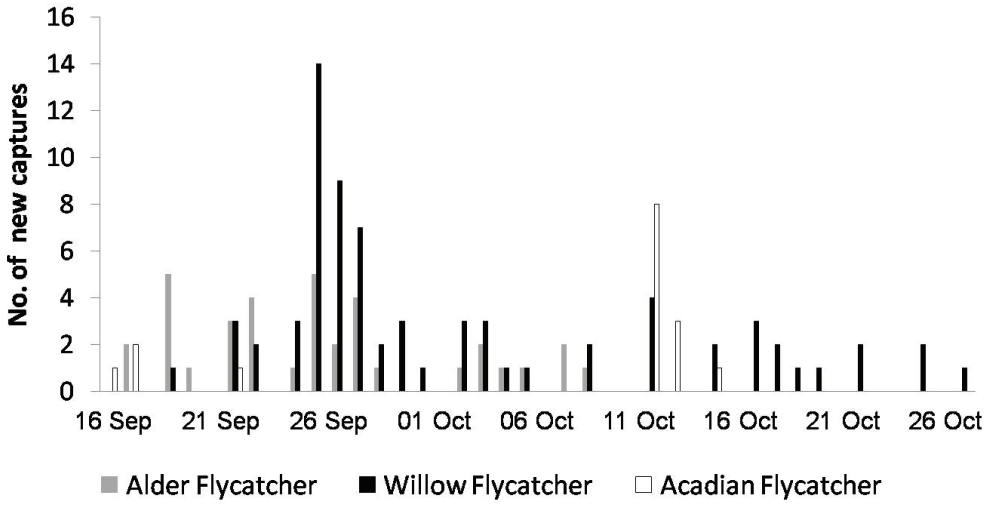

FIG. 1. Fall migration phenology, based on captures from constant effort mist-netting, of three transient species of *Empidonax* flycatchers in northeast Belize.

species and taking into account that most captures occurred in association with overnight precipitation (per. observ.), it may be that Acadian Flycatchers do not need to stop in northeast Belize given favorable weather conditions.

DISCUSSION

Comparing actual capture totals to expected capture totals revealed that Willow Flycatcher and Acadian Flycatcher were commoner than expected, while Alder, Yellow-bellied, and Least Flycatchers were rarer than expected in northeast Belize (Table 1). Bearing in mind that capture totals may have been affected by capture probability and habitat use, these differences can be considered representative of the relative affiliation of each species to a migratory route, e.g. to cross the Gulf of Mexico (trans-Gulf) to the Yucatán peninsula and continue southwards through northeast Belize during fall migration. Birds that follow a circum-Gulf route via Mexico rather than a trans-Gulf route would arrive in Belize from the north-west and west and consequently, unlike birds which adopt a trans-Gulf route, would not be expected to pass through our study site on their way to wintering regions in Central and South America. Under these assumptions, Willow Flycatcher would have a strong affiliation for a trans-Gulf route and Alder Flycatcher a weak one.

Affiliations inferred from our capture totals are supported by spatial probabilities of occurrence generated in eBird (Cornell Lab of Ornithology & National Audubon Society 2011). For example, Yellow-bellied Flycatchers are considered a common winter resident in southern Belize (Jones 2005) and yet we captured just one individual in northeast Belize giving rise to a low affiliation for a trans-Gulf route. The same is true of Least Flycatcher, a relatively common winter resident in our study area (Gómez-Montes & Bayly 2010). The probability of occurrence map for Yellow-bellied and Least Flycatchers during fall migration, suggest a high probability of occurrence along the Gulf coast of Texas and Mexico, indicative of a circum-Gulf route

TABLE 1. Capture totals during fall migration (2 September–10 November 2007), population estimates and expected capture totals of *Empidonax* flycatchers in northeast Belize. Population estimates were derived from Rich *et al.* (2004) and expected capture totals were calculated on the assumption that there was no difference in migratory route or capture probability between species.

Species	Population estimate	Fall captures	Expected captures
Acadian Flycatcher	4.7 million	16	7.8
Yellow-bellied Flycatcher	6 million	1	10
Willow Flycatcher	3.3 million	70	5.5
Alder Flycatcher	50 million	36	83.3
Least Flycatcher	14 million	7	23.3

(maps available in eBird: www.ebird.org). In contrast, Acadian Flycatcher, which has an affinity for the trans-Gulf route, has a high probability of occurrence along the eastern portion of the Gulf coast of the United States and not in Mexico.

The average body condition of captured birds suggests that they either needed to replenish their reserves before continuing migration or that they migrate by short hops. The small number of recaptures in this study, indicate that Willow and possibly Alder Flycatchers may replenish their energy reserves in our study area. Acadian Flycatchers carried larger fat deposits than the other two transient species and no individuals were recaptured, suggesting that birds may have only stopped due to unfavorable flight conditions.

One of our most striking observations was the complete lack of migrating *Empidonax* flycatchers during spring migration in northeast Belize. This is not totally unprecedented, as many species are known to alternate between different migration routes in fall and spring (Hutto 2000, Ruegg & Smith 2002), however, it is the first time that such variation has been reported for *Empidonax* flycatchers in the Neotropics. More study is needed to verify what routes those species with a fall affinity for a trans-Gulf route are taking in the spring, however, we hypothesize that the majority of individuals take an overland route around the Gulf of Mexico rather than passing through the Yucatán peninsula and subsequently crossing the Gulf of Mexico. This hypothesis is supported by capture totals in Veracruz, Mexico during spring migration (Martínez-Leyva *et al.* 2009). In addition, probability of occurrence maps generated in eBird for Willow Flycatcher, show that probabilities are higher in southeast Mexico and Texas than on the central Gulf coast of the United States in spring. The same is not true of Acadian Flycatcher and both capture totals in Veracrúz (Martínez-Leyva *et al.* 2009) and eBird maps indicate that birds are not adopting a circum-Gulf route. It is conceivable that Acadian Flycatchers could be refueling in regions to the south of our study site and subsequently overflying it, hence our failure to detect birds during spring migration.

Acknowledging that this is a one-year study and that migratory route and site use may vary between years (Dunn 2000, Martínez-Leyva *et al.* 2009), it would appear that during fall migration, our study area and, potentially by extrapolation, the Yucatán Peninsula, lies on an important migratory route for Willow Flycatcher. Further, the limited data we have on birds replenishing reserves, suggests that the stopover behavior of this declining yellow-listed species on the Yucatán warrants further investigation (Butcher *et al.* 2007). We also show that Acadian Flycatchers have an affinity for a trans-Gulf route to the Yucatán, although the larger energy reserves

TABLE 2. Body condition, expressed as fat score and body mass, of transient *Empidonax* flycatchers caught during fall migration (2 September–10 November 2007) in northeast Belize.

Species (n)	Fat score (0–8)		Body mass (g)
	Mean	Median	
Acadian Flycatcher (16)	2	2	13.9 ± 1.29
Willow Flycatcher (70)	1	0	11.4 ± 0.98
Alder Flycatcher (36)	1	0	12.1 ± 1.01

carried by this species suggest that stopover regions may lie to the south of our study area. For Yellow-bellied, Least and Alder Flycatchers, our data, combined with observations from eBird, indicate that a fall migration route around the Gulf of Mexico, avoiding our study region, may be the most prevalent. Finally, it would appear that an overland route around the Gulf is adopted by all species in the spring except for Acadian Flycatcher (Martínez-Leyva *et al.* 2009). These conclusions, though in need of further confirmation, are useful for fine tuning our understanding of the migration ecology and strategies of *Empidonax* Flycatchers outside of North America.

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