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THE BREEDING BIOLOGY OF THE FORK-TAILED FLYCATCHER (*TYRANNUS SAVANA*) IN LOWLAND PINE SAVANNA HABITATS IN BELIZE

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Resumen. – Biología reproductiva de la Tijereta Sabanera (*Tyrannus savana*) en las tierras bajas del hábitat de savana de pino en Belice. – Estudiamos la biología reproductiva de la Tijereta Sabanera (*Tyrannus savana*) en las tierras bajas del hábitat de savana de pino en Belice central. Condujimos la búsqueda y monitoreo de nidos y colocamos anillos durante la época reproductiva entre Abril y Agosto de 1999, 2000 y 2001. El estudio se realizó en dos sitios con hábitat similares, separados aproximadamente por 10 km. Sesenta y un nidos de la Tijereta sabanera fueron hallados y monitoreados. Basado en el número de huevos y/o polluelos presentes cuando se encontró el nido, el tamaño de la nidada en la mayoría de nidos fue de 3, con un rango de 1–4. El periodo de incubación varió entre 10.0 y 13.5 días y el de anidación de los polluelos varió de 16.5 a 18 días. La altura de nidos varió entre 0.4 y 9.6 m, mientras la altura de plantas con nidos varió entre 1.3 y 11.2 m. Entre las especies de plantas usadas para construir nidos se incluyen *Pinus caribaea*, *Crescentia cujete*, *Byrsonima crassifolia* y *Acoelorrhaphe wrightii*. Durante la época de búsqueda de nidos, pocos nidos fueron hallados a principios de Abril. La cantidad de nidos se incrementó a medianos de Abril hasta medianos de Julio, y luego se disminuyó a principios de Agosto. Tres de los cuatro individuos capturados durante la época reproductiva presentaron parche reproductivo, condición reproductiva. La probabilidad diaria de sobrevivencia fue de 0.951 y la de mortalidad fue 0.049. La probabilidad de éxito en el nido desde el inicio de incubación hasta el final de la anidación fue de 26.5%. El éxito reproductivo durante este estudio fue bajo, ya que solamente 7 de los 61 nidos estudiados (11.5%) produjeron volantones.

Abstract – We studied the breeding biology of the Fork-tailed Flycatcher (*Tyrannus savana*) in lowland pine savanna habitat in central Belize. We conducted nest searching, monitoring, and breeding season banding from early April to early August of 1999, 2000 and 2001. The study took place at two different sites approximately 10 km apart, but in similar habitats. Sixty-one nests of the Fork-tailed Flycatcher were found and monitored. Based on the number of eggs and/or nestlings present when the nest was found, the clutch size for the majority of nests was 3, with a range of 1–4. The incubation period ranged from 10.0 to 13.5 days, and the nestling period ranged from 16.5 to 18 days. Nest height ranged from 0.4 to 9.6 m and substrate height from 1.3 to 11.2 m. Plant species most commonly used as nest substrates included Caribbean pine (*Pinus caribaea*), calabash (*Crescentia cujete*), craboo (*Byrsonima crassifolia*), and palmetto (*Acoelorraphe wrightii*). During the nest-searching period, few nests were found in early April, nest numbers peaked from mid-April to mid-July, then declined in early August. During bird banding, three of the four Fork-tailed Flycatchers captured had a brood patch, indicating that they were in breeding condition at the time of banding. The daily probability of survival was 0.951 and the daily mortality rate was 0.049. The Mayfield probability of nest success from the start of incubation to fledging was 26.5%. Reproductive suc-

cess during this study was low, as only 7 of the 61 nests studied (11.5%) fledged young. *Accepted 13 October 2006*.

Key words: Belize, breeding biology, Fork-tailed Flycatcher, *Tyrannus savana*, nest success, pine savanna, incubation and nestling period.

INTRODUCTION

The Fork-tailed Flycatcher (*Tyrannus savana*) has four subspecies (*T. s. monachus, sanctaemartae, circumdatus* and *savana*), distributed from southern Mexico through much of South America, with the status of each race varying to include residents and/or movements that are nomadic, partially migratory and migratory (Fitzpatrick 2004). Fork-tailed Flycatchers have also been reported as vagrants in the United States and Canada, and of the 94 records believed to be valid, most are thought to involve the race *savana*, although a few records of *monachus* and one record of a *sanctaemartae* have been documented (McCaskie & Patten 1994).

The Fork-tailed Flycatcher is found primarily in pine savanna, but also occurs in cleared areas, open pinelands, pine-oak savannas, grassland habitats, second-growth scrub, pastures/agricultural lands, in the vicinity of marshes, and low, seasonally wet grassland areas (Paynter 1955, Russell 1964, Slud 1964, Stiles & Skutch 1989, Howell & Webb 1995, AOU 1998, Peterson & Robbins 1999, Jones 2003). Vickery *et al.* (1999) describe the Fork-tailed Flycatcher as a facultative grassland species. Fitzpatrick (2004) describes this species as also being found along rivers in heavily forested areas and using lawns, residential areas, mangroves, and river islands.

The subspecies *T. s. monachus* is distributed from southern Mexico south to Colombia and much of Venezuela, including several offshore islands, and is also found in south Surinam and north-central Brazil (Fitzpatrick 2004). In British Honduras (now Belize), Russell (1964) stated that data were not available to determine if the Fork-tailed Flycatchers breeding there were residents. However, *T. s. monachus* is now considered a common permanent resident in the following Belize districts: Belize, northern Cayo, northeast Toledo, Orange Walk and Stann Creek (Jones pers. com., Jones & Vallely 2001, Jones 2003). Limited information is available on the breeding biology of this species, as little ornithological work has been conducted within its preferred habitats, especially in the lowland pine savannas of Belize where this species is non-migratory. These savannas are under significant developmental pressure in Belize for use as citrus or banana plantations, gravel mining, logging, aquaculture, human settlements, and landfills (Boles 1999).

To learn more about the avifauna that utilize pine savannas in Belize, the Birds Without Borders – *Aves Sin Fronteras*® project undertook a comprehensive monitoring program in Belize from 1997 through 2002. As part of this research, we studied the breeding biology of the Fork-tailed Flycatcher during 3 seasons of fieldwork in lowland pine savanna habitats of central Belize. Herein, we present and discuss our findings.

STUDY SITES AND METHODS

Research was conducted on privately owned lands at two sites in central Belize. One site was located at the Tropical Education Center (17°21'26.9"N, 88°32'26.0"W) of the Belize Zoo and adjacent privately owned lands. This site was located in the Belize district at 46 m a.s.l. and encompassed an area of approximately 438 ha. The area used in this study consisted of 39.5 ha of lowland open pine

TABLE 1. Monthly rainfall from 1999 to 2001 at two Belize sites where Fork-tailed Flycatcher (*Tyrannus savana*) breeding biology was studied.

Site	April	May	June	July	August
Tropical Education Center	106.5[a] (19.8-193.2)	187.1 (35.9-298.9)	204.4 (58.7-285.7)	315.0 (285.1-344.9)	295.3 (155.9-454.2)
Runaway Creek Nature Preserve[b]	53.7 (29.8-94.2)	159.0 (12.5-246.0)	218.0 (86.7-322.4)	265.4 (170.5-328.1)	328.3 (204.1-423.3)

[a]Mean monthly rainfall and (range) in mm.
[b]Rainfall was measured 10 km from the study site.

savanna with areas of shrubland with pine. A strip of gallery forest 15–20 m wide traversed the northern section of the study area. Caribbean pine (*Pinus caribaea*), palmetto (*Acoelorraphe wrightii*), savanna poisonwood (*Cameraria latifolia*), black poisonwood (*Metopium brownei*), and cutting grass (*Scleria bracteata*) were the dominant plant species. Graminoids and low shrubs dominated the low ground cover.

The second site was located at the Runaway Creek Nature Preserve (17°18'05.1"N, 88°27'31.8"W), a 2500 ha preserve owned and managed by the Foundation for Wildlife Conservation, Inc. It was located 10 km east of the Tropical Education Center study site at 16 m a.s.l. The Runaway Creek Nature Preserve was dominated by two distinct vegetation types: tall semi-evergreen or evergreen forest and savanna (Meerman 1999). Of the approximately 500 ha of pine savanna habitat present at the Runaway Creek Nature Preserve, 40 ha were utilized for this study. This study area consisted of open pine savanna, shrubland with pine, and pine-oak forest. Dominant plant species included Caribbean pine, live oak (*Quercus oleoides*), palmetto, schippea palm (*Schippia concolor*), yaha (*Curatella americana*), craboo (*Byrsonima crassifolia*), and calabash (*Crescentia cujete*). Graminoids and herbaceous plants dominated the low ground cover. The savanna was dry during the dry season, but temporary ponds, wetlands, and flowing water were prevalent during the rainy season.

Our Belize breeding biology study was conducted from early April to early August in 1999 through 2001. This included the latter portion of the February to May dry season and a portion of the June to October rainy season, which peaks in July (Central Statistical Office, Belize 2001). At each study site rainfall varied considerably among years during April and May and was highest from June to August (Table 1).

Nest searching and monitoring was based on a modification of the Breeding Biology Research and Monitoring Database (BBIRD) protocol. BBIRD is a national, cooperative voluntary program that provides standardized field methodologies for studies of nesting success across North America (Martin *et al.* 1997). To facilitate the relocation of nests, a permanent nest-searching plot was established and demarcated at 50 m intervals with an alphanumeric grid system. The Tropical Education Center nest plot measured 9 ha in 1999 and was enlarged to 39.5 ha in 2001. The Runaway Creek Nature Preserve nest plot was 32 ha in 2000 and was enlarged to 40 ha in 2001. Nest searching was conducted 5 days per week, commencing from just before sunrise and continuing until approximately 09:30 h CST depending on weather conditions. To locate nests, researchers systematically

FIG. 1. Nest of the Fork-tailed Flycatcher (*Tyrannus savana*) in Belize: (A) Nest with eggs, (B) Side view of the nest.

searched the nest plot by walking slowly and looking for signs of a possible nest, such as parental behavior (e.g., a pair consistently in one area), carrying of nesting material or food, or noisy behavior of nestlings. Nests were monitored when found and then every 3–4 days unless a transition was expected, in which case nests were monitored every two days. To minimize disturbance and the risk of predation, nests were monitored from a distance when possible, and as quickly as possible. Care was taken not to leave a dead-end trail to the nest, and to observe the general area for any sign of possible predators, particularly avian predators, prior to approaching the nest. When necessary, nest contents were observed using a mirror mounted on a telescoping pole. If the nest was still too high to view the contents, behavioral observations were used to monitor breeding activity. Nest and substrate height were measured with a measuring tape (low nests) or a clinometer (high nests).

Because complete information on nesting chronology was not available for each nest, we used the suggestions outlined by Martin *et al.* (1997) to calculate the incubation and nestling periods. The incubation period was defined as the period from the day that the last egg was laid until the first egg hatched and the nestling period from the day the first egg hatched through the day that the young fledged. The number of days the nest was under observation was calculated to the nearest half-day (noon or midnight) and, if the exact transition date was not known, the midpoint between nest visits was used to estimate when critical events in the nesting cycle such as nest stage transition, fledging or failure occurred (e.g., For a nest that was in the incubation stage on 4 May and had hatched by the next check on 7 May, the estimated hatch date was midnight on 5 May).

Measurements of survival and reproductive success were calculated using the following methods: daily mortality rate (Mayfield 1961, 1975); daily survival probability (Hensler & Nichols 1981); variances (Johnson 1979, Hensler & Nichols 1981); and nest success probability from incubation to fledgling

TABLE 2. Summary of final nest stage and outcome of 61 Fork-tailed Flycatcher (*Tyrannus savana*) nests found from 1999 to 2001.

Final nest stage	Outcome	Number of nests
Before egg-laying	Abandoned	3
Before egg-laying	Destroyed	3
Unknown if reached egg-laying	Destroyed by fire	1
Unknown if reached egg-laying	Destroyed, removed, or on ground	17
Egg-laying or incubation	Abandoned	1
Egg-laying or incubation	Depredated	18
Nestling	Fledged (successful)[a]	7
Nestling	Depredated (failed)	4
Nestling	Unknown[b]	2
Unknown[c]	Unknown	5

[a] A nest was considered successful if at least one bird fledged.

[b]These nests contained nestlings at the end of the field season and were not monitored further to determine the outcome.

[c]For four of these nests, the stage and outcome were not determined; they were too high to see the contents. For one nest, insufficient data was recorded to determine the outcome.

(Mayfield 1961, 1975). Per the recommendations in Manolis *et al.* (2000), the periods used in these calculations, the number of exposure days, and the number of failed, successful and uncertain nest fates are included in this report.

Bird banding was conducted every 6–10 days during the nest-searching period based on the methods of the British Constant Effort Sites (Baillie 1990, Peach *et al.* 1996) and Monitoring Avian Productivity and Survivorship (MAPS) Program (Burton & DeSante 1998). Banding took place in the savanna and on the edge of the gallery forest at the Tropical Education Center site and in the savanna and shrubland with pine at the Runaway Creek Nature Preserve site. Ten nets were operated for 3–5 h each day depending on weather conditions. Resident birds, including the Fork-tailed Flycatcher, were marked with numbered aluminum bands. Breeding condition was determined by the presence of a brood patch in females or cloacal protuberance in males, which were assessed using the criteria described in Burton & DeSante (1998).

RESULTS

Nest and egg descriptions. Nest building took approximately 4–6 days. A nest with eggs is shown in Figure 1a and a side view of the nest is shown in Figure 1b. The nest consisted of a shallow, oval, woven cup of dry twigs, vines, graminoids, and a few strands of pine needles. Soft, fine dried flowers and fluffy, cotton-like flowers were embedded around the exterior part of the nest. The nest interior was lined with graminoids and a few hair-like twig strands. One nest was measured and the external nest length at the longest axis was 10.5 cm and the width at the shortest axis was 9.0 cm. The internal nest length was 6.5 cm and the width was 6.0 cm. The depth of the nest cup was 4.8 cm.

To minimize disturbance, one representative egg from a clutch of three was measured. The egg was smooth and oval in shape. The egg length was 23 mm at the longest point and the diameter was 16 mm at the widest circumference. Egg color was white with brownish [vinaceous-russet (Ridgway 1912 plate

TABLE 3. Nest substrate, number of nests, nest and substrate height of Fork-tailed Flycatcher (*Tyrannus savana*) nests.

Nest substrates	Number of nests	Nest height (m)	Substrate height (m)
Caribbean pine (*Pinus caribaea*)	15	1.1-9.6	1.4-10.8
Calabash[a] (*Crescentia cujete*)	10	1.2-3.3	1.6-5.0
Craboo (*Byrsonima crassifolia*)	9	1.0-2.8	1.4-3.5
Palmetto (*Acoelorraphe wrightii*)	8	1.4-3.5	2.0-4.0
Savanna poisonwood (*Cameraria latifolia*)	3	1.2-3.0	1.4-3.5
Yaha (*Curatella americana*)	2	1.5	2.0
Calea sp.	1	1.4	2.8
Cocoplum (*Chrysobalanus icaco*)	1	0.4	2.3
Heisteria media	1	1.1	1.4
Live oak (*Quercus oleoides*)	1	5.5	11.2
Coccoloba sp.	1	1.6	3.2
Caesalpinia sp.	1	1.2	1.3
Quiina schipii	1	1.0	1.3
Turneria ulmifolia	1	1.4	1.7
Unknown species[b]	6	1.1-1.9	1.3-2.0
Total number of nests	61		

[a]One of the nests was built in an orchid (*Schomburgkin tibicinis*) that was growing on a calabash (*Crescentia cujete*).

[b]One nest was destroyed by a savanna fire and one was removed and assumed to be depredated; vegetation studies could not be completed on either of these nests. Samples were collected for identification on the other four unknowns but could not be identified.

XXVIII)] streaking at the top of the wider end and a few brownish spots at the narrow end.

Clutch size, incubation, and nestling period. Of the 61 nests found during this study, 25 (41.0%) contained eggs or nestlings and could be included in the calculation of clutch size. Fifteen (60.0%) of these 25 nests contained three eggs, four (16.0%) nests had two eggs, two (8.0%) nests contained one egg, one (4.0%) nest contained four eggs, two (8.0%) nests had two nestlings each when found (indicating that at least two eggs were laid) and one (4.0%) nest had two nestlings visible when monitored (indicating that at least two eggs were laid). This yielded a clutch size of 1–4 eggs (mean = 2.6, SD = 0.71, N = 25). None of the nests was parasitized by cowbirds, although both the Bronzed Cowbird (*Molothrus aeneus*) and the Giant Cowbird (*M. oryzivorus*) were observed at the Tropical Education Center site. The Giant Cowbird was observed only once at the Runaway Creek Nature Preserve site.

The mean incubation period was 12.63 days (SD = 1.75, N = 4, range = 10.0–13.5). The mean nestling period was 17.38 days (SD = 0.63, N = 4, range = 16.5–18).

Nest success. Outcomes of the 61 nests are listed in Table 2. Thirty-two (52.5%) nests reached at least the egg-laying or incubation stages, 13 (21.3% of total) reached the nestling stage and 7 (11.5%) successfully fledged at least one young. Twenty-two (36.1%) nests were depredated; of these, eight were destroyed or torn apart, seven were intact,

three were on the ground, one nest was removed and could not be found, and in one nest the nestlings were missing but one egg remained. No descriptions were recorded for the other two depredated nests. In addition to these depredated nests, 20 nests were destroyed, found on the ground or were removed during or shortly after the building stage so that we were unable to determine if eggs were laid in these nests. Overall, of the 61 nests found during this study, 23, or 37.7% were destroyed. One additional nest was destroyed by a savanna fire. We observed three nests being destroyed by Brown Jays (*Cyanocorax morio*) or Tropical Kingbirds (*Tyrannus melancholicus*). For the other failed or destroyed nests, the cause of failure or the predator was not determined.

Twenty-four of the 61 nests reached the incubation stage and their contents could be seen when monitored. These 24 nests could be included in the calculations of daily probability of survival, daily mortality rate, and nest success probability. The daily probability of survival was 0.951 (N = 24 nests, total exposure days = 329.28, total nests lost = 16, variance = 0.00014, 95% confidence interval = 0.928–0.975). The daily mortality rate was 0.049. The probability of nest success was 26.5% (N = 24 nests, mean observation days = 13.7, range of observation days = 2–31.5, total exposure days = 329.28, variance = 0.0081, 95% confidence interval = 0.09–0.44). The mean incubation and nestling periods listed above were used for these calculations.

Nest substrate. Results of nest substrate are summarized in Table 3. Fourteen plant species (plus six unidentified species) were used as nest substrates. The most commonly used substrates included Caribbean pine, calabash, craboo, and palmetto. Substrate height ranged from 1.3 m to 11.2 m. Within the nest substrates, nest height ranged from 0.4 to 9.6 m. The majority of nests (86.0%) were built in the upper 50% of the substrate.

Breeding season bird banding. During the breeding season bird banding (April–August), four Fork-tailed Flycatchers were captured and banded. One bird captured in May was not in breeding condition, while two birds captured in June and one bird in July had brood patches, indicating that they were breeding in the area (Brewer *et al.* 1991).

DISCUSSION

Nest construction. Although daily observations were not conducted at the Fork-tailed Flycatcher nests during our study (to reduce the likelihood of abandonment during the nest-building stage), it appeared that nest building took approximately 4–6 days. This is consistent with Mason (1985), who studied Fork-tailed Flycatcher reproduction in Argentina and found that at least 5 days seemed to be necessary for nest construction.

The measurements of Fork-tailed Flycatcher egg length and width in this study are comparable to those cited in Wetmore (1972), Mason (1985), Cruz & Andrews (1989) and Mezquida (2002).

Wetmore (1972: 376) described a Fork-tailed Flycatcher nest as a "shallow cup of plant fibers padded with fluffy down" and that "leaves may be woven into the outer edge." Mason (1985) described the nest of the Fork-tailed Flycatcher as a grass cup high in trees. Belton (1985: 80) described three nests, one of which was made of wool with perhaps some garden paineira (*Chorisa* sp.) mixed in, another was "made of sticks" and a third "appeared to be made of woven grasses." Due to our higher sample size, we provide a more detailed description of the Fork-tailed Flycatcher nest than these previous studies. Our nest measurements are

similar to those described in Fitzpatrick (2004).

Belton (1985: 80) proposed that the paineira fibers woven into the nest "ideally disguised" it. The nests found by Wetmore (1972) and in our study had dried leaves or flowers woven into the exterior, which also may have aided in making the nest more cryptic.

Nest substrate. In addition to the garden paineira described above, Belton (1985) reported another nest in an exotic conifer, but he did not provide descriptions of the habitats in which these nests were found. Mezquida (2002) found two nests in algarrobo trees (*Prosopis flexuosa*) and three in chañar trees (*Geoffroea decorticans*), which were the sparsely distributed trees present in the "bosque abierto" he studied. He did not report Fork-tailed Flycatcher nests in the medium-sized trees or low shrubs also present in this habitat. Caribbean pine, calabash, craboo, and palmetto were the plants utilized most often as nest substrates in our study. The availability of these dominant pine savanna plant species probably explains why they were more commonly used as nest substrates.

In our study, nests were built at 0.4–9.6 m, mainly in the upper 50% of substrates that ranged from 1.3 m to 11.2 m in height. Although nest and substrate heights in our study had a wider range, the position of our nests within the substrate is comparable to Mezquida (2002), who described Fork-tailed Flycatcher nest heights from 3.2 $\pm$ 0.3 (SE) m to 3.5 $\pm$ 1.0 m within substrates that ranged from 4.2 $\pm$ 0.4 m to 5.3 $\pm$ 0.3 m in height. Other studies describe the heights of Fork-tailed Flycatcher nests, but do not describe the relationship between nest and substrate height. These nest height descriptions include: < 1–10 m (Wetmore 1972), 2.1–6.5 m (Mason 1985), 5–20 m (Belton 1985), and 1–10 m (Stiles & Skutch 1989).

Clutch size, incubation and nestling periods. Based on the 25 nests found in this study in which the contents were seen and that reached at least the egg-laying stage, we determined that the clutch size of the Fork-tailed Flycatcher in Belize was 1–4 (mean = 2.6). This differs from Mason (1985), who reported a mean clutch size of 3.2 in Argentina, with the range being 3–4, and with Stiles & Skutch (1989) who reported the clutch size in Costa Rica to be 2–3 eggs. These differences could be explained by our larger sample size. Our description of egg color coincides with that of Wetmore (1972) and Mason (1985).

Ricklefs (1969) reported that the incubation and nestling periods of birds in the tropics are on average about 10% longer than those in the temperate zone. Skutch (1985) also reported that tropical birds have longer incubation and nestling periods than temperate birds. In our study, we found that the incubation period for the Fork-tailed Flycatcher ranged from 10.0 to 13.5 days (N = 4) and the nestling period ranged from 16.5 to 18 days (N = 4). This contrasts with two studies conducted in Argentina: Mason (1985) described a mean phase duration of 15 days for incubation (N = 7) and Mezquida (2002) reported an incubation period of 14 days (N = 1) and nestling period of 13 days (N = 2). In these and our study, the sample size used to determine the incubation and/or nestling periods was low ($\leq$ 7), and it is possible that the duration of incubation and nestling periods may vary among pairs and among years based on the weather and the resultant food availability. Therefore, more study is necessary to determine the range of variation of incubation and nestling periods for this species.

Of the 442 birds of 61 species captured during breeding season bird banding, only

four were Fork-tailed Flycatchers. To minimize the visibility of the mist nets and to avoid exposure to direct sunlight, the majority were placed near the edge of the gallery forest, in the shrubland with pine, and pine-oak forest, rather than in the open pine savanna. Fork-tailed Flycatchers were common in open pine savanna, but were less common in the areas where the nets were set, which may explain why so few were captured.

Geographic variation in breeding biology. The optimal time for reproduction is during the period in which food is abundant, which in seasonal areas of the tropics is the wet season (Cruz & Andrews 1989). During the wet period in the tropics there is a seasonal flush of vegetation and insects (Immelmann 1971). Thus, it would benefit birds to coordinate their breeding efforts with this seasonal increase of food, regardless of whether they are residents or migrants. Breeding reports from areas in which Fork-tailed Flycatchers are mainly residents have come from the Central American countries of Belize, Costa Rica and Panama. In Belize, Russell (1964) described four nests with eggs or young from 31 March to 22 May and one nest with a female incubating eggs on 29 June. In our study, breeding activity was documented throughout the early April through early August study period; however the majority (54, or 88.5%) of nests were found from mid-April to mid-July. Of four birds captured during this study (April to August), three had brood patches during June and July. In Belize, it appears that Fork-tailed Flycatchers began breeding near the end of the February to May dry season and continued into the rainy season, which extends from June to October, peaking in July. On the Pacific slope of Costa Rica, Fork-tailed Flycatchers are resident and nest from May to June, which correlates with the May–June rainy season (Stiles & Skutch 1989). Wetmore (1972) summarized his breeding observations and those of others in Panama and described Fork-tailed Flycatcher mating displays in January, active nests from February to June and fledglings or immature birds in late May and June. This breeding activity began during the December to April dry season and continued into the May to December rainy season (Oxford Univ. Press 2004).

In South America, some Fork-tailed Flycatcher populations may be resident, while others are migratory. In Colombia, Hilty & Brown (1986) state that the Fork-tailed Flycatcher may be a resident with numbers augmented by post-breeding middle-American birds. They summarized reports of Fork-tailed Flycatchers breeding in Colombia and described nests with eggs in February and May and an observation of a juvenile in February. These reports were from different areas of the country and the weather in Colombia is quite variable among the coastal zones, inland areas and Andes Mountains; so it is not possible to correlate these breeding records with the timing of heaviest rainfall. In Rio Grande do Sul, Brazil, Belton (1985) described the Fork-tailed Flycatcher as a summer resident that arrives in late September and departs in February. He summarized breeding records that included copulation on 28 October and active nests (eggs or nestlings) or fledglings from 12 November through 24 January. Rainfall in this area of Brazil is distributed throughout the year, with slightly more than average during late winter (July–September) and slightly less in the remaining months of spring and early summer (October–December) (Belton 1985). It appears that in this area of Brazil, Fork-tailed Flycatchers began breeding during the early spring and summer during the time of slightly less rainfall. In Venezuela, large numbers of the *Tyrannus savana savana* subspecies that are austral migrants are present from March to mid-October, although some *T.s. monachus* may breed there (Hilty 2003). In northern Apure state, Vene-

zuela, two Fork-tailed Flycatcher nests were found in October, during the second half of the May to October rainy season (Cruz & Andrews 1989). The Fork-tailed Flycatcher is a migrant in Argentina (Fitzpatrick 2004). In east-central Argentina, Mezquida (2002) studied five nests and reported that the first egg was laid 9 November and the last 25 December, during the period of highest rainfall that occurs from October to March. In Buenos Aires Province, Argentina, nests with eggs and nestlings were found in December and January; however rainfall records there do not show a pronounced rainy season (Mason 1985).

Fork-tailed Flycatchers feed primarily on flying insects (Fitzpatrick 2004), and during the wet season the seasonal growth of vegetation and the resultant peak in insect abundance provides an increase in their primary food. Based on the majority of breeding reports described above, it appears that both resident and migratory Fork-tailed Flycatchers begin their breeding cycle either late in the dry season, or near the beginning of or during the wet season, most likely to take advantage of the increased availability of this food supply. This burst of insects would provide abundant food when it is most needed for nestlings, fledglings, and independent juveniles.

During our study, Fork-tailed Flycatcher reproduction in Belize began near the end of the dry season and continued into the rainy season. We do not know if the breeding season of the Fork-tailed Flycatcher at our study sites began before or extended beyond the end of our April to August nest-searching periods. Extending the nest-searching and banding study periods could help to determine the complete breeding season for this species in Belize.

Nest success in pine savanna. Low reproductive success and high predation rates are not uncommon in tropical birds (Skutch 1985). In our study of the Fork-tailed Flycatcher, only 7 (11.5%) of the 61 nests studied fledged young. The Mayfield (1961, 1975) probability of nest success from incubation to fledging was also low (26.5%). This low probability of nest success contrasts with high reproductive success probability (72.3%) found for the Gray-crowned Yellowthroat (*Geothlypis poliocephala*), a species that was studied during the same time period in the same habitat (Martinez *et al.* 2004). The low reproductive success of the Fork-tailed Flycatcher may be due to the higher visibility of their nests, built in trees or shrubs in areas of open savanna. Gray-crowned Yellowthroat nests studied were difficult to locate in graminoid tussocks near the ground (Martinez *et al.* 2004).

In our study, predation was the likely cause of failure in 22 (36.1%) of the 61 Fork-tailed Flycatcher nests. Although snakes have been described as being important avian nest predators (Skutch 1985, Weatherhead & Blouin-Demers 2004, Robinson *et al.* 2005), snakes were not observed in the nest plots during nest searching and monitoring or during vegetation studies. However, our fieldwork took place mainly before 12:00 h and Robinson *et al.* (2005) observed six of eight snake predation events after 14:00 h.

Multiple nesting attempts by tropical birds are not uncommon (Skutch 1985). In our study, a low number of nests (3, or 4.9%) that appeared to be completely built were abandoned before egg-laying occurred. Four individual Fork-tailed Flycatchers were observed removing nesting material from abandoned Fork-tailed Flycatcher nests and using the material to build another nest within 50 m of the abandoned nest. Because the birds were not marked for individual recognition, it could not be determined whether the birds building the new nest were those that had also built the abandoned nest. It is possible that

some birds made several nesting attempts before building a nest that was used for egg-laying.

Conservation implications. Belize is a relatively small country (22,963 km^2) in Central America, but it supports a rich avifaunal diversity of approximately 574 species (Jones 2003), a significant percentage of which are secure and not of conservation concern there (Miller & Miller 1997). However, the avifaunal diversity of central Belize could be at risk by ongoing developmental pressures that threaten the lowland pine savanna habitats (Boles 1999). Vickery *et al.* (1999) classified the Fork-tailed Flycatcher as a "facultative grassland species" that, although not entirely dependent on grasslands, uses them "commonly and regularly" as part of a wider array of habitats. Few large-scale studies of the breeding biology of the Fork-tailed Flycatcher have been conducted; so, other than those reported above, it is not known which other habitats are commonly utilized by this species for reproduction. In our study, Fork-tailed Flycatchers were observed utilizing the pine savanna habitats for all aspects of their breeding cycle, including courtship displays, gathering of nest materials and nest building, incubation, brooding, as well as feeding and caring for fledglings. As a result, until more is known about the breeding biology of this species in other habitats, it is essential to stress conservation of Belize's pine savanna habitats in conservation and land-management plans in order to protect this documented breeding habitat of the Fork-tailed Flycatcher.

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