Nocturnal Flight Behavior of Waterbirds in Close Proximity to a Transmission Powerline in the Florida Everglades

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Abstract.—Many birds move at night, and although there is strong potential for collisions with stationary structures, the behavior of birds in response to such structures is poorly understood. We studied the nocturnal interactions of waterbirds with a 550v transmission powerline in the flat, open landscape of the Florida Everglades using a combination of surveillance radar to detect incoming birds, and night vision optical equipment to observe flight behavior. During 118 hours of observation we recorded a total of 285 flocks of ciconiiform birds crossing the powerline during spring 1997. We visually observed 663 birds in 187 flocks, and documented their response to the powerline. We found that the flight directions and the colony site locality strongly suggested regular nocturnal foraging behavior of some species, especially Black-crowned Night Herons (*Nycticorax nycticorax*) and Wood Storks (*Mycteria americana*). Birds flying at night were less likely to react to the powerline, suggesting that powerlines may pose more of a collision threat during darkness. However, we also found that waterbirds flew higher at night than during the day and thus came into a zone of potential contact with the powerline much less often than during the day. *Received 8 April 2001, accepted 3 July 2001.*

Key words.—Waterbirds, nocturnal, powerline, collision, radar, Everglades.

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Many diurnal birds are known to be active for part or all of the night, as a result of migratory activity (Able 1974), entrainment to tidal cycles or prey activity (Black and Collopy 1982; Erwin 1977; Robert *et al.* 1989; Dodd and Colwell 1996), compensation for variation in daylight activities (Lane and Hassall 1996) or avoidance of diurnal predators (Lima 1993; Thibault and McNeil 1994, 1995). Nocturnal activity seems particularly variable in waterbirds, among which nocturnal foraging and movements may vary according to species (Avery *et al.* 1977), season (Dodd and Colwell 1996), predation pressure, or human disturbance (Burger and Gochfeld 1991).

Powerlines and other structures often constitute a collision hazard for birds (Scott *et al.* 1972; Willard *et al.* 1978; Brown *et al.* 1987; Faanes 1987). The risk of birds colliding with powerlines or other structures at night may be considerably higher than during daytime because of reduced visibility. Avise *et al.* (1981) estimated that over 42,000 birds died by colliding with a TV tower in Leon County, Florida between 1955-1980. Maehr *et al.* (1983) reported a kill of 3,000 birds underneath two pairs of chimneys on a single overcast night during autumn migration in central Florida. Although many of these cases may be linked to abnormal weather conditions or distraction by lights, the impact of the powerlines and other structures to the nocturnal movement of wild birds is of interest due to rapid increases in the number of towers and other structures being constructed. Nocturnal collisions can be inferred from systematic morning-after carcass searches (Morkill 1991; Alonso *et al.* 1994; Brown *et al.* 1995; Janss *et al.* 1998), but these methods are subject to considerable bias due to scavenging and crypticity of carcasses (APLIC 1994). Direct observation of nocturnal avian behavior around powerlines and towers should allow better understanding the nature of the interaction and the possibility for ameliorating avian collisions.

In an effort to better understand the behavior of night-flying ciconiiform birds, we used a combination of radar surveillance and night vision optics to study avian interactions with a newly constructed high-voltage powerline in the Everglades of Florida. Our study area was immediately adjacent to several large roosts and breeding colonies of waterbirds, providing an opportunity to look

at the behavior of large numbers of breeding birds that crossed the powerline regularly. Here, we report on the frequency of night flights, and compare the behavior of night-flying birds to powerlines with daytime observations.

METHODS AND STUDY SITES

We conducted nocturnal observations along a 3.7 km section of a transmission powerline constructed in 1996 as ten 370m-long spans in the northeastern Florida Everglades (Broward Co, FL, immediately east of SR 27). This line was supported by H-frame towers of reinforced concrete, with three bundles of transmission lines carried by major arms on either side, and two thinner ground wire cables (used to guide lightning to the ground) on the top of the structure, totalling about 45m in height (see Fig. 1). The powerline is in typical Everglades wet prairie marsh habitat, with Cattail (*Typha* spp) and Sawgrass (*Cladium jamaicense*) dominating the emergent vegetation. This habitat is extremely flat and open, and trees are only occasionally encountered on elevated roadways and widely dispersed islands. We made nocturnal observations mainly within 3.5 hours after sunset and before sunrise, three times a week between 20 February and 11 July 1997. We used a small surveillance marine radar instrument, (Furuno FR-7111, 10 kw, 1.8-m antenna, powered by 12v batteries) mounted on a research vehicle. We drove the radar to a point below the top of a 6 m high dike to block ground-clutter (Williams 1984). We used an Excalibur Model 602, GEN III night vision monocular (NVM) with changeable power of 1× and 3×, and a pair of 10 × 50 binoculars, to directly observe the behavior of birds passing the powerline. We placed the mobile radar at randomly chosen locations along the 3.7-km section of powerline each night, and monitored two spans simultaneously. The radar was placed one half span (about 200 m) away from the closest span being visually observed. One observer operated the radar to detect approaching birds and to document the total traffic volume of birds crossing the powerline. A second observer used the NVM or binoculars from a position underneath the focal part of the powerline. The radar operator informed the visual observer of approaching targets via handheld CB band radio. We also recorded weather information once every hour.

We used a chi-square test of independence to compare the rates of waterbirds that had no reaction to the powerline, or that flew above the level of the ground wire, during daylight and darkness.

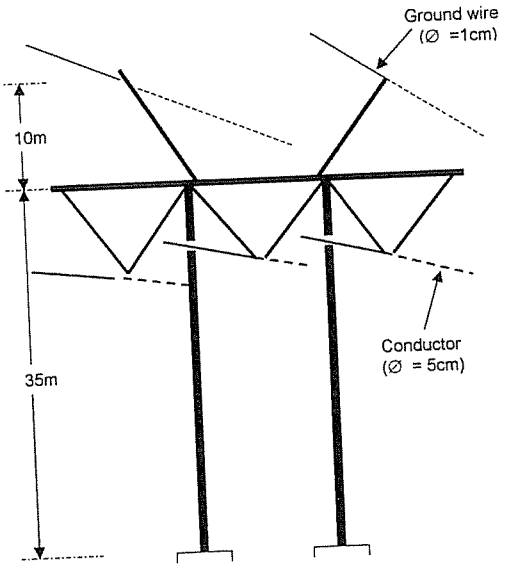

Figure 1. Schematic of the H-frame towers supporting the 550 kV transmission powerline. Three conductors, with a diameter of 5cm each, are carried on the arm, and two ground wires run on the top of the tower. The ground wires, which are used for guiding the lighting to the ground, are generally thin, about 1cm in diameter and spaced above the more visible conductors, causing most of the bird collision with the powerlines.

RESULTS

We counted a total of 285 flocks (singletons or cohesive groups) of birds on the radar screen, and visually observed a total of 663 birds in 187 flocks during 118 hours of nocturnal observation over a period of six months. We estimate that on average twelve flocks crossed the 3.7-km-long section of powerline per hour of observation. None of the birds we observed collided with the powerline. Since the radar observer always alerted the visual observer to incoming flocks, the difference in numbers of flocks recorded by radar and those recorded by NVM or binocular demonstrated that at night many birds were not visible from the ground. Since the radar picked up birds at a wide range of altitudes, this result suggests that many of the birds were flying higher than the 70-m distance at which we estimated we could see birds using optics. Nocturnal activity was highest in February at approximately 26 flocks/h and gradually dropped to about 5 flocks/h in June and July (Fig. 2A). This is most parsimoniously explained by the overall seasonal decline of the wetland bird numbers in the Everglades during that time, as suggested by our daytime observations (Deng 1998), and by systematic counts of birds over the entire area. Among the total of 663 birds, 63% were White Ibis (*Eudocimus albus*), 11% were Black-crowned Night Heron (*Nycticorax*

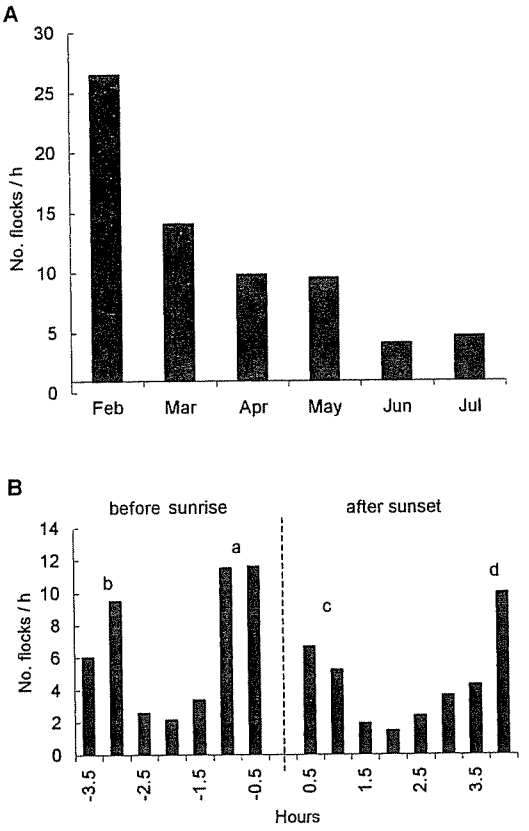

Figure 2. Distributions of nocturnal activity (number of flocks/h) of waterbirds crossing a 3.7 km section of powerline recorded by radar. A. Change of nocturnal activity over a six-month period. Nocturnal activity started highest in February, reached about 26 flocks/h and gradually dropped to about 5 flocks/h in June and July. B. Change of nocturnal activity during the 3.5 h before sunrise (designated by the negative numbers) and 4 h after sunset (designated by positive numbers). *a*, *b*, *c* and *d* indicate the most active period. The dotted line divides the morning and evening.

nycticorax), 8% were Great Blue Heron (*Ardea herodias*), and 8% were Wood Stork (*Mycteria americana*) (see Table 1).

Frederick (1995) conducted surveys of the wading bird colonies in the Everglades, and found that nearly all of the colonies in our study area were located on the west side of the powerline, except scattered very small colonies (2-80 pairs) dominated by small *Egretta* herons. During diurnal observations along the same powerline (Deng 1998), it was noticed that an overwhelming majority of diurnally flying waterbirds traveled in an easterly direction in the morning and westerly direction in the evening. Therefore, birds crossing the powerline in an easterly direction could be interpreted as traveling from colonies to foraging areas, while those traveling in a westerly direction were likely to be returning to colonies after feeding. We therefore defined a "Nocturnal Tendency" (NT) index as the percentage of birds flying toward foraging grounds at night and roosting and breeding sites in the morning, divided by the total number of individuals of a species recorded. We used the NT index as a relative index of the likelihood of the species to be nocturnal forager.

During the 3.5 h before sunrise and 4 h after sunset, there was a distinct drop in per-hour frequency of all flights, as recorded on radar, close to the mid-point of each period (Fig. 2B). These may reflect the shifts between the activity of nocturnal and diurnal waterbirds. Peaks *a* and *c* in Fig. 2B were contributed mostly by both diurnal and nocturnal waterbirds heading in opposite directions. Specifically, diurnal foragers tended to start their foraging an hour before sunrise, and to extend their return to roost or colony to one hour after sunset. The increases in activity illustrated by *b* and *d* in Fig. 2B suggest that nocturnal activity remained somewhat constant throughout the night, starting from about 3 h after sunset to about 3 h before sunrise. Almost all the White Ibis observed visually were concentrated in the hour before sunrise (Fig. 3A), and the relatively low flight frequency during the evening suggests that most White Ibis returned to colonies prior to sunset. Although we recorded 423 White Ibis during the nocturnal observation, they had an extremely low NT index of 0.2%. Both nocturnal species, Black-crowned Night Heron and Wood Stork, showed similar characteristics of nocturnal activity (Fig. 3B, C). Black-crowned Night Herons had the highest NT index of 87%, followed by Wood Storks at 85% (Table 1).

Frequency of flights after sunset was relatively constant throughout our observation periods. Flight frequencies of Great Blue Herons well in advance of sunrise and well after sunset demonstrated that some unknown proportion of the individuals of this

Table 1. List of waterbirds recorded in the proximity to a transmission powerline in the Florida Everglades during nocturnal observation in 1997, and percentage of birds of each species whose direction suggested nocturnal foraging.

Species		Total	Percent of total	NT index*
Black-crowned Night Heron	*Nycticorax nycticorax*	76	11.4%	87%
Green-backed Heron	*Butorides striatus*	6	0.9%	17%**
Tricolored Heron	*Egretta tricolor*	10	1.5%	0%
Little Blue Heron	*E. caerulea*	6	0.9%	17%**
Snowy Egret	*E. thula*	21	3.2%	0%
Great Egret	*Ardea albus*	14	2.1%	0%
Great Blue Heron	*A. herodias*	55	8.3%	24%**
Wood Stork	*Mycteria americana*	52	7.8%	85%
White Ibis	*Eudocimus albus*	423	63.4%	0.2%
Total		663	100%	19%

*NT index (Nocturnal Tendency index = Percentage of birds flying toward foraging ground at night and roosting sites in the morning divided by the total number of individuals of a species recorded;

**Species may not be applicable to the "NT index" as a result of nesting in the study area.

species were active, and probably foraging during the night (Fig. 3D). It is important to remember that we were unable to identify the birds flying higher than 70 m above the ground using our NVM or binoculars; this may have led to a bias in the above analysis if there were species-specific differences in nighttime flight altitudes.

We found that nocturnal waterbirds were less responsive to the powerline than were diurnally flying birds. Overall, 98.4% of the total 667 nocturnal waterbirds did not respond to the powerline by showing easily visible behavioral reactions, compared with 83.6% of 28,941 waterbirds observed during daylight in the same location (Deng 1998) ($\chi^2 = 101$, $P < 0.001$). This reflected the reduced visibility of the powerline to the nocturnal waterbirds and may imply a higher risk of collision for night-flying birds.

However, we also found that birds were more likely to cross the powerline above the ground wires at night than during the day. In all, 87.0% of the 639 birds for which we recorded flight height flew above ground wires when crossing the powerline at night, comparing with 81.8% of 34,546 birds in the day ($\chi^2 = 10.5$, $P < 0.01$). The actual nocturnal rate is likely to be even higher than suggested by this comparison, since we recorded, via radar, 98 flocks of birds unobserved by NVM or binoculars which flew higher than the ground wire (34% of all flocks).

DISCUSSION

We have demonstrated that many waterbirds regularly fly at night in the Everglades during the breeding season, and that there were important species differences in this regard. Black-crowned Night Herons are known to be nocturnal (Davis 1993), and both Bent (1926) and Coulter *et al.* (1987) noted foraging behavior by Wood Storks on moonlit nights. A closely related African species, the Yellow-billed Stork (*Mycteria ibis*), also has shown nocturnal foraging behavior (Fasola and Canova 1993). The very low NT index we found for White Ibis suggested that they were strict diurnal foragers, also in accordance with other descriptions (Kushlan and Bildstein 1992). Rojas *et al.* (1999) reached the same conclusion using comparative eye morphology. Although Great Blue Herons are widely reported to forage at night (Black and Collopy 1982; Butler 1992), we were unable to establish a true NT index for this species because nesting in the study area was dispersed and irregular relative to our observation post (Frederick 1995).

We have also showed that night-flying waterbirds tended to fly higher than they did during the day when crossing the powerlines. By flying higher at night, waterbirds may lower the collision risk by simply avoiding any interaction with powerline or other tall structures. This was also suggested by Bruderer

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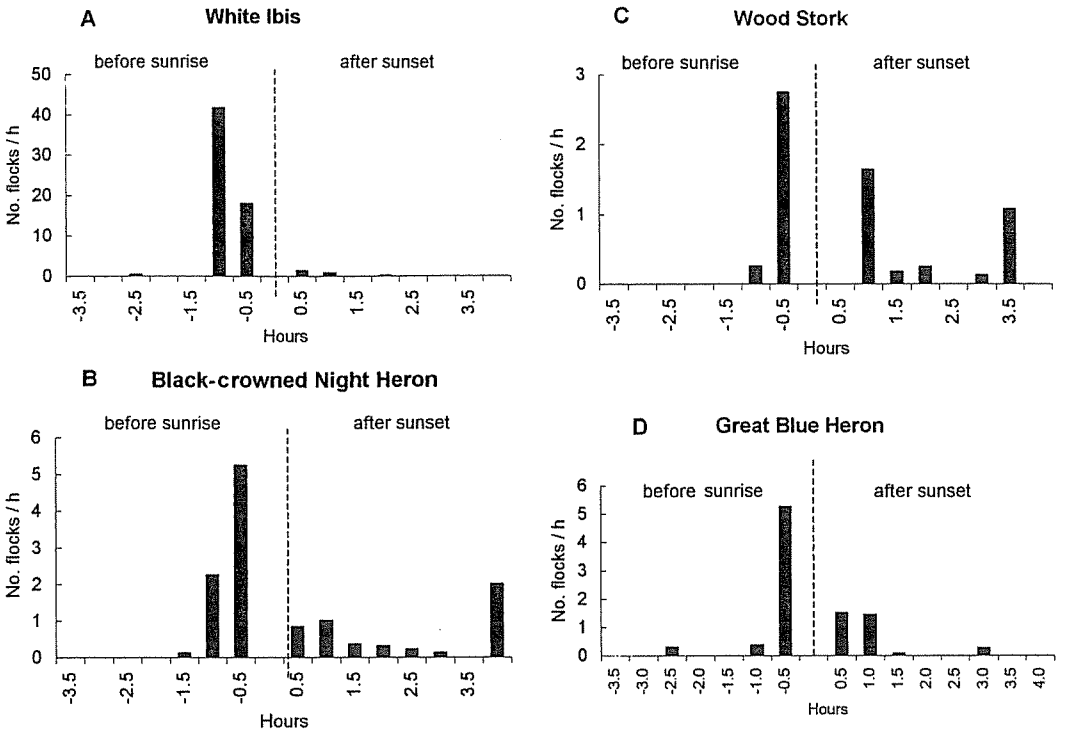

Figure 3. Distributions of nocturnal activity (number of birds/h) of waterbird species crossing a 3.7 km section of powerline visually observed by NVM or binocular. Negative numbers on the x-axis designates the hours before sunrise, and positive numbers designates hours after sunset. The dotted line divides the morning and evening. A. White Ibis; B. Black-crowned Night Heron; C. Wood Stork; D. Great Blue Heron.

(1997), who found that nocturnal migration of passerines occurred at about 700 m altitude, while diurnal flights averaged only about 400 m. Using tracking radar, Blokpoel (1971) found that nocturnal migrants concentrated at a height of 600-1,200 m.

We did not observe any collisions during our nocturnal observations, which may suggest a relatively low impact of the powerline to the waterbirds in this area. However, we caution that our study was relatively short in duration, and covered a small section of powerline. There could also be behavioral differences between migratory birds and birds at a wintering or breeding ground. The waterbirds we studied were probably familiar with the powerline from daily experience with it in daylight and darkness, and they may have adjusted their behavior accordingly. Such familiarity with the local environment could significantly reduce the risk of collision when comparing resident and migratory birds. We also caution that since collisions may be dependent on height and configuration of the powerline, prevailing weather patterns and local topography, our findings should not necessarily be extended to other types of powerlines in other areas, or to other species.

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