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Ecology

Patterns of nocturnal bird migration in southern Mexico

Patrones de migración nocturna de aves en el sur de México

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Abstract

The Isthmus of Tehuantepec is the narrowest landmass between the Gulf of Mexico and the Pacific Ocean. It is known as an important stopover site and migration corridor for Nearctic-Neotropical migratory birds. We characterized nocturnal bird migration along the Pacific side of the isthmus with marine radar, and identified species with diurnal point counts during 5 fall seasons (2009–2013) at operational and proposed wind farms. We found significant differences in migratory traffic rates, flight directions, and flight altitudes among years and sites, but we also found patterns of similarity including flight directions heading to the southeast each season; migratory traffic rates peaking 3–4 h after sunset and decreasing thereafter; flight altitudes increasing throughout the night; seasonal mean flight altitudes fluctuating between ~520 and ~720 m above ground level (m agl); and <7% of detected targets flying below 100 m agl. Our data suggest that migratory activity initiates around mid-September and peaks in mid-October. We identified 58 bird species of nocturnal migrants. Studies of nocturnal bird migration are important for understanding potential impacts from wind farms.

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Keywords: Isthmus of Tehuantepec; Marine radar; Oaxaca; Wind farm

Resumen

El istmo de Tehuantepec es la masa continental más estrecha entre el golfo de México y el océano Pacífico. Es conocido como sitio de descanso y corredor migratorio importante para aves migratorias neárticas-neotropicales. Nosotros caracterizamos la migración nocturna de aves en la vertiente del Pacífico del istmo utilizando un radar marino e identificamos especies utilizando puntos de conteo diurnos, durante 5 temporadas migratorias de otoño (2009–2013) desde distintos parques eólicos en operación y propuestos. Encontramos diferencias significativas en la tasa de flujo migratorio, direcciones y alturas de vuelo entre años y sitios, pero también encontramos patrones de similitud incluyendo direcciones de vuelo hacia el sureste cada temporada; tasas de flujo migratorio teniendo un pico 3–4 h después de la puesta del sol y disminuyendo después; alturas de vuelo incrementando a lo largo de la noche; alturas de vuelo promedio en cada temporada fluctuando entre ~520 y ~720 m sobre el nivel del suelo, y <7% de los blancos detectados volando por debajo de 100 m sobre el nivel del suelo. Nuestros datos sugieren que la actividad migratoria se inicia a mediados de septiembre y tiene un pico a mediados de octubre. Identificamos 58 especies de aves que tienen hábitos migratorios nocturnos. Los estudios sobre migración nocturna de aves son importantes para entender posibles impactos de parques eólicos.

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Palabras clave: Istmo de Tehuantepec; Radar marino; Oaxaca; Parques eólicos

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Introduction

Almost half of the bird species that inhabit the US travel south to winter in the Neotropics every year (Rappole, Morton, Lovejoy, & Ruos, 1983). These include a wide range of taxonomic groups, from small passerines that depend on powered flight to raptors that use thermal wind updrafts for soaring flights (Gill, 2007). Differences in flight style between these 2 groups of birds are related to the time of day used for migration: while soaring birds (e.g., raptors) almost always migrate during daytime, powered fliers (e.g., passerines) are predominantly nocturnal migrants (Kerlinger, 1995).

Some migratory flyways used by Nearctic-Neotropical nocturnal migrants converge at the Isthmus of Tehuantepec (UNEP, 2009), the narrowest landmass between the Gulf of Mexico (GOM) and the Pacific Ocean (~220 km at its narrowest stretch). Located in southern Mexico, the Isthmus of Tehuantepec has been considered “an avenue for migrants moving between North and South America”, and both the GOM and Pacific lowlands are thought to be “important wintering areas for North American migrants” (Binford, 1989).

The Isthmus of Tehuantepec is part of the transitional area between the Nearctic and Neotropical realms (Ríos-Muñoz, 2013) with its local topography playing an important role in creating major differences between slopes. The Sierra Madre Oriental and Sierra Madre del Sur run parallel to the GOM and Pacific coastlines, respectively; these important ridgelines meet at the western side of the isthmus, continuing to the east under the name of Sierra Madre de Chiapas (Barber & Klicka, 2010) after being interrupted by a low elevation gap known as Chivela Pass. One of the characteristics that define the identity of each slope is a gradient in barometric pressure, which is consistently higher in the GOM throughout the year (Steenburgh, Schultz, & Colle, 1998). This promotes a constant flow of wind toward the Pacific through the Chivela Pass (Chelton, Freilich, & Esbensen, 2000), creating a rain shadow on the northward side of the mountain range, and promoting the establishment of rain forests in the GOM side of the isthmus (Rzedowski, 1990). In contrast, the Pacific side is characterized by a dryer climate and tropical deciduous forests (Conabio, 1998).

In the last decade, the Pacific side of the isthmus has gained much relevance due to its high potential for wind-energy production (Alemán-Nava et al., 2014; Elliott et al., 2003; Jaramillo & Borja, 2004), promoting avian studies on different topics (Villegas-Patracca, Cabrera-Cruz, & Herrera-Alsina, 2014; Villegas-Patracca, MacGregor-Fors, et al., 2012; Villegas-Patracca, Macías-Sánchez, Macgregor-Fors, & Muñoz-Robles, 2012), but few have been published regarding the flow of nocturnal migrants. Cabrera-Cruz, Mabee, and Villegas-Patracca (2013a) published the first reports on nocturnal bird migration for the area, derived from radar observations made from a single site during one fall season, but with no information on the species migrating through the area.

The objective of this study is to describe the patterns of nocturnal migratory traffic rates (MTR), defined as the number of targets passing across 1 km of migratory front per hour (targets/km/h), flight directions, flight altitudes, and species of

nocturnal migrants observed from the Pacific side of the Isthmus of Tehuantepec, within one of the most important Wind Resource Areas of Mexico (Alemán-Nava et al., 2014). For this, we used data collected with a single marine radar unit and point counts during 5 consecutive fall seasons (2009–2013), from different operational or proposed wind farms, under request by different wind-energy companies that were required to carry out environmental studies by the environmental authorities of Mexico. This work also aims to make public information that otherwise would remain in gray literature, informing society, conservation organizations, decision makers, and others interested in bird migration in the region.

Materials and methods

We studied bird migration from different sites within the Wind Resource Area of the Isthmus of Tehuantepec, an area that extends from the Pacific Ocean coast northward approximately 60 km, and approximately 60 km to 80 km from east to west (Elliott et al., 2003), centered approximately around the town of La Ventosa. The main vegetation type is a matrix of pastureland, sorghum crops, and fragments of tropical deciduous forest, which was the original vegetation type in the area (Muñoz-Jiménez, 2014).

We monitored nocturnal bird migration with the aid of a marine radar adapted as a mobile unit, operating during a different number of nights throughout 5 fall migratory seasons (2009–2013), and identified bird species with morning point counts. Our study sites were distributed around ~17 km route of coastal plain, delimited to the north by the Tolistoque ridgeline and to the south by the Laguna Superior (Fig. 1). Radar monitoring stations were located in flat terrain either within operational or proposed wind farms and in sites where surrounding vegetation acted as a partial radar fence to reduce ground clutter contamination.

Given that our radar monitoring was made under request by different wind-energy companies, each year we worked from different sites but always within the Wind Resource Area of the Pacific coastal plains of the isthmus. In 2009 and 2010, we monitored nocturnal bird migration from a single site throughout the season (La Venta II and Unión Fenosa, respectively), visiting each site daily during the whole field season. In 2011, 2012 and 2013 we had 3, 2 and 3 monitoring sites, respectively, and we alternated our daily visits among sites to conduct the observations because we only had 1 radar unit. For example, our first night of observations in 2011 was at La Venta II, the next night we visited Oaxaca 1, and the following night we visited Alesco; we repeated this sequence throughout the duration of our field season.

At the time of our observations, La Venta II was an operational wind farm whose area was composed by a matrix of pastureland, sorghum crops, and patches of deciduous dry forest (16°35'29.45" N, 94°48'41.91" W; 36 m asl). In 2010, we worked at Unión Fenosa, at the time it was an area proposed for the development of a wind-energy project; most of its area was covered by deciduous dry forest but also had portions of

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