Revista Brasileira de Ornitologia 26(3): 196–201.
September 2018

ARTICLE

Enhancing our knowledge on the Ornate Hawk-Eagle (*Spizaetus ornatus*) through community-based monitoring records from tropical Mexico

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Received on 26 June 2018. Accepted on 06 October 2018.

ABSTRACT: The Ornate Hawk-Eagle *Spizaetus ornatus* is a rare Neotropical raptor. In Mexico its distribution is irregular, its biology is poorly known, and it is considered to be threatened by extinction. We provide novel and supplementary information, resulting from community-based bird monitoring projects, on the natural history of the species from different regions of Mexico. We characterize the location of several nests of the species, describe a new altitudinal record for its presence and breeding range, and add information about its breeding habits and prey consumption. Anthropogenic disturbances that negatively affect the Ornate Hawk-Eagle mainly include land use change and hunting. Local and regional information on the species is essential to have a broad understanding of its biology and to improve the implementation of conservation strategies. Promoting community-based monitoring projects could enhance research capabilities and conservation efforts on this and other cryptic species of conservation concern.

KEY-WORDS: breeding cycle, citizen science, conservation, cryptic species, natural history, Neotropical raptor.

INTRODUCTION

The Ornate Hawk-Eagle *Spizaetus ornatus* is a rare Neotropical raptor that inhabits tropical forests from Mexico to Argentina (Brown 1976, Ferguson-Lees & Christie 2005, Bierregaard-Jr. *et al.* 2018). Its cryptic behavior and its preference for undisturbed, heavily-vegetated ecosystems, has hindered a complete understanding of its natural history (Iliff 2010). Although scarce, observations on its nesting and feeding habits are available from Central and South America (Kiff & Cunningham 1980, Lyon & Kuhnigk 1985, Klein *et al.* 1988, Naveda-Rodríguez 2004, Joenck *et al.* 2011, Phillips & Hatten 2013). However, the Ornate Hawk-Eagle is poorly known in Mexico, the northern limit of its range (Howell & Webb 1995). In this country, its distribution is irregular, almost no information exists about its natural history, and it is considered to be threatened by extinction (Aranda *et al.* 2009, SEMARNAT 2010). As a result, there is a need to gather biological data on the species to understand its general habits, its ecological plasticity, and its local habitat preferences (López-González *et al.* 2004, Aranda *et al.* 2009). Moreover, regional information on the species might provide the opportunity to contextualize local research and socio-political strategies for its conservation.

In this study we provide novel and supplementary information on the natural history of the Ornate Hawk-Eagle from different regions of Mexico. In particular, we characterize the location of several nests of the species that were found in distinct ecosystems. Moreover, we describe a new altitudinal record for the presence and the

breeding range of the species. We also add information about its breeding habits and prey consumption. As this manuscript is a result of the collaboration between local bird monitors and ornithologists, we recommend the association between society and scientists through community-based biological monitoring projects to expand our knowledge of cryptic species of conservation concern.

The origin of the data

The information included in this manuscript comes from community-based bird monitoring projects performed in Mexico. For a detailed description of these projects see Ortega-Álvarez *et al.* (2012, 2015, 2018a, 2018b). Data was gathered by experienced local bird monitors during both casual sightings and bird monitoring surveys. Ornithologists assisted monitors in the course of these activities. Observations on the Ornate Hawk-Eagle were performed in three different regions of Mexico: Reserva de la Biosfera El Cielo (referred to as "El Cielo" hereafter), Reserva de la Biosfera Los Tuxtlas (referred to as "Los Tuxtlas" hereafter), and Sierra Juárez.

El Cielo is a natural area protected by the Mexican Government located at the state of Tamaulipas, northeastern Mexico (Gobierno del Estado de Tamaulipas 2013). It covers an area of 144.540 ha that includes tropical forests, scrublands, grasslands, Oak and Pine Forests, cloud forests, riparian vegetation, and secondary vegetation. It houses an important number of plant and animal species. Los Tuxtlas is located at the state of Veracruz, southeastern Mexico (CONANP 2006). It is a natural area protected by the Mexican Government that covers a surface of 155.122 ha. It is a very important reserve for its high biological diversity. The reserve is composed of different ecosystems, including tropical forests, cloud forests, Oak and Pine Forests, grasslands, mangroves, coastal dunes, and secondary vegetation. Finally, Sierra Juárez is a region located in the state of Oaxaca, southern Mexico, where indigenous and rural communities own and manage a large percentage of the most biologically important forests of Mexico (Anta-Fonseca & Merino 2003, Anta-Fonseca 2007). Main vegetation types in the region include tropical forests, cloud forests, Oak and Pine Forests, scrublands, and secondary vegetation.

Breeding biology of the Ornate Hawk-Eagle

The breeding biology of the Ornate Hawk-Eagle is still incomplete and it varies regionally (Iliff 2010). We detected and characterized the location of six nests of the species in different regions of tropical Mexico. Four of these nests were located in El Cielo, one in Los Tuxtlas, and one in Sierra Juaréz (Table 1). As reported by previous studies, nests were situated at mid to high-levels (mean ± standard error SE = 28 ± 2.55 m) below the canopy of tall trees (38.2 ± 3.19 m). Our observations at El Cielo suggest that Oak trees might be of primary importance for the species, even among different ecosystems (*e.g.*, Pine-Oak Forests, cloud forests, tropical medium semideciduous forests). Although most nests were found in forested areas set aside for conservation purposes, the nest of Los Tuxtlas was established in a restored site. This site was previously used for ranging livestock about 25 years ago. All the local vegetation was removed at that time, with exception of the current nesting tree. The restored site is now covered by secondary vegetation. This suggests that the Ornate Hawk-Eagle might not be completely dependent on old forests, and may be keen to use restored areas for breeding.

The literature mentions that this raptor has a clutch size of a single egg under natural conditions (Kiff & Cunningham 1980). Nevertheless, we detected two young birds at the nests of Sierra Juárez and El Cielo. This suggests that the species might be able to have a larger clutch size if natural conditions are favorable (*e.g.*, availability of prey), as found for other birds of prey (Olsen & Marples 1992). However, we also observed that a unique chick survived and developed into a juvenile when eagles had a clutch size of two. Similar to other raptors, mortality of chicks might be associated with food supply, prey density, and cainism (Collopy 1984, Janes 1985, Simmons 1988). The breeding pairs that we recorded nested only once per year. As the timing of breeding of the Ornate Hawk-Eagle varies throughout America (Iliff 2010), in Table 2 we provide a general description of its breeding cycle according to our notes from tropical Mexico.

Altitudinal distribution

The Ornate Hawk-Eagle regularly ranges from the sea level to 1800 m a.s.l. (Iliff 2010). However, wanderers have been recorded in Costa Rica as high as 3000 m a.s.l. (Stiles & Skutch 1989). Wandering individuals are usually immatures, which are likely to disperse away from breeding areas (Iliff 2010); we still regularly recorded adult individuals in Oak and Pine Forests at Sierra Juárez from 2300 to 2900 m a.s.l. Moreover, the nest that we found in this region was located at 2307 m a.s.l. (Table 1). This suggests that the species ranges and breeds at higher altitudes, at least in some regions of its northern range.

Hunting and prey observations

According to the literature, this species mainly feeds on avian prey. Nevertheless, it also captures mammals, lizards, and even snakes (Klein *et al.* 1988, Clinton-Eitniear *et*

Table 1. Habitat characterization of the nests of the Ornate Hawk-Eagle (*Spizaetus ornatus*) found in tropical Mexico. All nests were active, thus their precise locations are not provided for conservation purposes. The height, diameter, and species' name of the tree that supports the nest are specified. Nest height represents the distance between the ground and the base of the nest. The age of the nest represents the number of years that have passed since the nest was found up to mid-2018. **Nest "1" was relocated by the breeding couple about two years ago. The previous nesting site was located about 50 m away from the actual site, and it was used by the couple for at least 15 years.

Habitat trait	Nest ID number					
	1	2	3	4	5	6
Region	El Cielo	El Cielo	El Cielo	El Cielo	Los Tuxtlas	Sierra Juárez
Altitude (m a.s.l.)	835	714	897	1445	251	2307
Land use	Conservation	Conservation	Conservation	Conservation	Restoration	Conservation
Supporting tree	*Quercus germana*	*Quercus germana*	*Quercus germana*	*Quercus germana*	-	*Pinus pseudostrobus*
Tree height (m)	35	26	38	40	50	40
Tree diameter (m)	1.2	1.6	2.0	1.9	-	1.3
Nest height (m)	30	20	30	35	-	25
Nest age (years)	2**	7	10	3	2	3
Vegetation	Tropical medium semideciduous forest	Tropical medium semideciduous forest	Cloud forest	Pine-Oak Forest	Tropical Rainforest	Oak-Pine Forest
Dominant trees	Fig (*Ficus* sp.), Oak (*Quercus* spp.)	Fig (*Ficus* sp.)	Redgum (*Liquidambar* sp.), Oak (*Quercus* spp.), Ash (*Fraxinus* sp.), Avocado (*Persea* sp.), *Podocarpus* sp.	Pine (*Pinus* spp.), Oak (*Quercus* spp.), Cypress (*Cupressus* sp.)	*Heliocarpus appendiculatus*, *Cupania macrophylla*, *Senna multijuga*	Pine (*Pinus* spp.), Oak (*Quercus* spp.), Alder (*Alnus* sp.), Avocado (*Persea* sp.), *Oreopanax* sp.

al. 1991, Acosta-Chaves *et al*. 2012, Whitacre 2012). In the regions where we performed our observations, we recorded the Ornate Hawk-Eagle preying largely on birds, including Great Curassow (*Crax rubra*), Crested Guan (*Penelope purpurascens*), Military Macaw (*Ara militaris*), Cattle Egret (*Bubulcus ibis*), White-tipped Dove (*Leptotila verreauxi*), Red-billed Pigeon (*Patagioenas flavirostris*), Tuxtla Quail-Dove (*Zentrygon carrikeri*), tinamous (Tinamidae), and domestic poultry. Still, the eagle occasionally takes as prey White-nosed Coati (*Nasua narica*), squirrels (Sciuridae), rabbits (Leporidae), lizards, and snakes.

The Ornate Hawk-Eagle remains silent and immobile below top of the forest canopy when it hunts, as mentioned by Brown (1976) and Ferguson-Lees & Christie (2005). However, it usually flies in circles above the forest when it moves from one hunting ground to another. We have recorded intra-specific agonistic interactions for the species, particularly among individuals of different ages (*i.e.*, adults *vs.* juveniles), which might be related with dominance relationships and territoriality (Griffin 1981, Rothfels & Lein 1983). However, we did not observe negative interactions between the Ornate Hawk-Eagle and other raptor species. In fact, we have seen the Ornate Hawk-Eagle sharing hunting territories with Short-tailed Hawks (*Buteo brachyurus*), Gray Hawks (*Buteo plagiatus*), Solitary Eagles (*Buteogallus solitarius*), and White Hawks (*Pseudastur albicollis*). Moreover, we have recorded nests of Gray and White Hawks closely located to those of the Ornate Hawk-Eagles, suggesting that such species also share their breeding grounds.

Conservation concerns

We have observed different human activities that have both positive and negative effects on the Ornate Hawk-Eagle. For instance, ecological restoration initiatives performed by local communities in Los Tuxtlas may provide suitable nesting and foraging sites for the species, as it has been observed nesting and hunting in restored sites that were previously used for ranging livestock. Moreover, as evidenced by camera traps (Fig. 1A, B), the construction of water fountains by communities in El Cielo has proven to be successful in attracting Ornate Hawk-Eagles and other animal species, as this type of infrastructure provides important water supplies for wildlife, mainly during the dry season.

Anthropogenic disturbances occurring within our study sites that negatively affect the Ornate Hawk-Eagle mainly include land use change and hunting. The conversion of forests to rangelands, cropfields, and urban settlements represents a key force (Cairns *et al.*

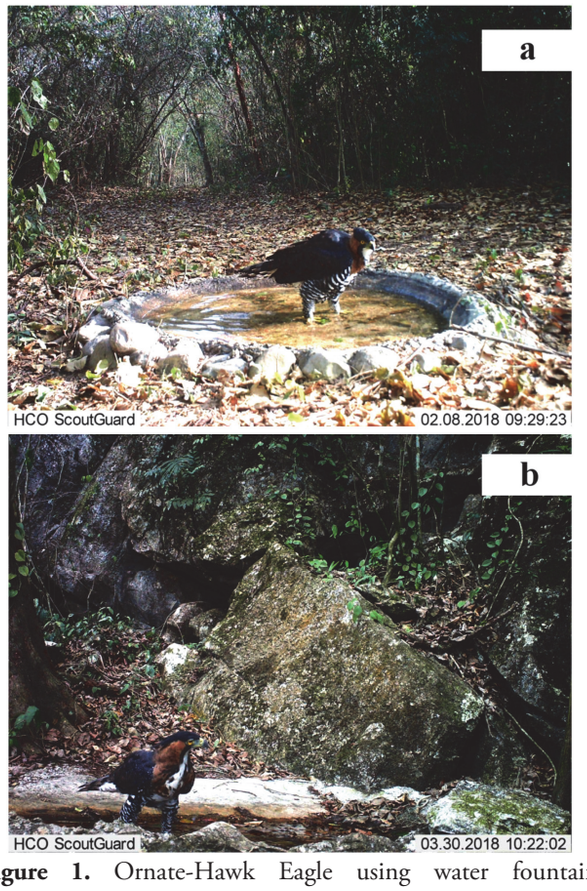

Figure 1. Ornate-Hawk Eagle using water fountains constructed by local communities in El Cielo. Photographs were obtained by camera traps.

2000) reducing the habitat for the species. In addition, hunting is another threat to the Ornate Hawk-Eagle as it is both appreciated as a trophy (Iñigo-Elías *et al.* 1987, Aranda *et al.* 2009, Forcey & Aragón 2009) and is sometimes perceived as a threat for poultry (Trinca *et al.* 2008), despite the fact that it rarely takes this type of prey. Furthermore, poaching on other animals might also indirectly affect this species, as we have seen it scared by hunting dogs. Nevertheless, more research should be performed to evaluate the actual effects of those disturbances associated with poaching (*e.g.*, noise, prey depletion, alteration of community structure; Dulvy *et al.* 2004, Chapron *et al.* 2008) on the Ornate Hawk-Eagle.

Conclusions

Although our observations may be useful in improving our knowledge of the Ornate Hawk-Eagle, more systematic analyses are needed to fulfill our understanding of the species. We suggest that local and regional information on the Ornate Hawk-Eagle is essential to have a complete understanding of its biology and to improve the implementation of conservation strategies for protecting the species and its habitat. The promotion of community-based monitoring projects could be useful in enhancing the research capabilities and conservation efforts on this and other species throughout the region.

Table 2. Timing of breeding of the Ornate Hawk-Eagle (*Spizaetus ornatus*) in tropical Mexico.

Breeding event	Month	Observations
Courtship displays	February	-
Nest-building	February	The species might re-use the same nest for several years. Nest reconstruction is performed by the couple by using green branches of trees located at the surroundings of the old nest.
Mating	March	The couple mates for several times during this time of the year.
Egg-laying	March–April	-
Incubation	April	-
Hatching	April	-
	May	By this month, the chick can hold its head up and show up from the nest.
Fledging	August	The young starts to perform short-distance flights, always staying close to the nest. It is very noisy as it constantly calls the parents for food.
Juvenile explores surroundings	September–December	Juvenile is quite able to fly and starts to move away from the nest. However, it still receives food from the parents.
	January	The juvenile gets more silent and solitary. However, it is still possible to observe the juvenile and the parents together.
Juvenile independence	February–March	Parents force the juvenile to abandon the nesting area. They may attack the young if it refuses to leave. In extraordinary occasions, the juvenile manages to stay in the surroundings of the nest, even if the parents start to raise a new chick.

ACKNOWLEDGEMENTS

We are grateful to the UZACHI and the communities of Capulálpam de Mendez, Santiago Xiacui, Santiago Comaltepec, and La Trinidad de Ixtlán for their support to the project associated with this manuscript. To Dulce A. Paz Acosta, Rubén Ortega Gaytán, Patricia Álvarez, Juan Andrés Figueroa, Laura Jiménez, la *Tropa Pajarera de El Cielo*, and the *Red de Monitoreo Comunitario Huilotl Toxtlan* for all their assistance. To Eleanor Goldberg and Malcolm Burson for editing the English grammar of the paper. We thank two anonymous reviewers for their critical review that improved the early version of this manuscript. As part of the *Posgrado en Ciencias Biológicas* of the UNAM, RO-A received a Ph.D. Scholarship from CONACYT (327503). We thank Luis Fernando Martínez García, Mario Alberto Alvarez Lara and Esteban Berrones Benitez for the photographs of the Ornate-Hawk Eagle.

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Associate Editor: Cristiano S. Azevedo.