ORIGINAL ARTICLE

OCCUPANCY, RELATIVE ABUNDANCE, AND ACTIVITY PATTERNS OF GREAT CURASSOW (*CRAX RUBRA*) IN SOUTHEASTERN MEXICO

Gabriela Pérez-Irineo[1] · Antonio Santos-Moreno[2]

[1]Independent Researcher. Primer Andador Secretaría de Estado 9, Federal Burocrática, Huixquilucan, Estado de México, 52777, México.

[2]Laboratorio de Ecología Animal, Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Unidad Oaxaca del Instituto Politécnico Nacional, Hornos 1003, La Noche Buena, Santa Cruz Xoxocotlán, Oaxaca, 71230, México.

E-mail: Gabriela Pérez-Irineo · gabyirineo@yahoo.com.mx

Abstract · The Great Curassow (*Crax rubra*) plays a key role in the regeneration of Neotropical forests through seed dispersal and predation of several plant species. Due to poaching, habitat loss, and fragmentation, *C. rubra* is globally at risk, and has become rare or locally extinct throughout of its range. Viable populations may occur in southeastern Mexico, particularly in Los Chimalapas region, in the state of Oaxaca, but this has not yet been verified. Recently, camera traps have been used for ecological studies of cracids, and other birds in the understory of rain forests. Our aim was to document the occupancy, relative abundance, and activity patterns of *C. rubra* in the understory of a tropical rain forest in Los Chimalapas region, through data gathered from camera traps. We gathered data from 27 camera traps and used occupancy models to analyze the effect of microhabitat on the detection (the probability that at least one individual of a species will be detected, given that the species inhabits the area of interest) and occupancy (the probability that a randomly selected site or sampling unit contains at least one individual of the species) probabilities. The best model indicated that *C. rubra* detection probability was higher in sites with higher records of a potential predator, the margay (*Leopardus wiedii*). The occupancy probability of *C. rubra* was 0.94 (SE = 0.06), and its detection probability ranged from 0.08 (station with zero records of *L. wiedii*) to 0.79 (stations with 27 records of *L. wiedii*). This association may be due to *L. wiedii* tracking the abundance of a potential prey (i.e., *C. rubra*) or because both species select sites with similar structural components of vegetation. Other models showed lower support, such as those models linking the presence of *C. rubra* to other predators and human presence. The species was mainly recorded as solitary individuals and showed more frequent activity in the morning and afternoon. The presence of chicks and juveniles suggest that there are suitable conditions for the establishment of a reproductive population of *C. rubra* in the region. Los Chimalapas still has connections with both, conserved (i.e., Selva El Ocote Biosphere Reserve) and highly deforested areas (i.e., the Uxpanapa region), and should be a priority region for *C. rubra* conservation.

Resumen · Ocupación, abundancia relativa y patrón de actividad del Hocofaisán (*Crax rubra*) en el sureste de México
El Hocofaisán (*Crax rubra*) juega un importante papel en la regeneración en los bosques Neotropicales a través de la dispersión y depredación de varias especies de plantas. Debido a la intensa cacería, pérdida de hábitat, y fragmentación, *C. rubra* está en riesgo y llega a ser rara o extirpada localmente en varias partes de su área de distribución. Se piensa que pueden encontrarse poblaciones viables en el sureste de México, particularmente en la región de Los Chimalapas, en el estado de Oaxaca, pero esto aún no ha sido verificado. Recientemente las trampas cámara han sido usadas para los estudios ecológicos de crácidos y otras aves en el sotobosque de los bosques tropicales. Nuestro objetivo fue documentar la ocupación, abundancia relativa y patrón de actividad de *C. rubra* una selva alta en la región de Los Chimalapas, a través de datos generados por las trampas cámara. Obtuvimos datos de 27 sitios con trampas cámara y usamos los modelos de ocupación para analizar el efecto del microhábitat en las probabilidades de detección (probabilidad de que al menos un miembro de la especie sea registrado, dado que la especie habita el área de interés) y ocupación (probabilidad de que un sitio o unidad de muestreo seleccionado al azar contenga al menos un individuo de la especie). El mejor modelo indicó que la probabilidad de detección de *C. rubra* fue alta en sitios con más registros de un depredador potencial, el margay (*Leopardus wiedii*). La probabilidad de ocupación de *C. rubra* fue 0.94 (SE = 0.06) y la probabilidad de detección varió de 0.08 (sitios sin registros de *L. wiedii*) a 0.79 (sitios con 27 registros de *L. wiedii*). Esta asociación puede deberse a que *L. wiedii* sigue a una presa potencial abundante (i.e., *C. rubra*) o porque ambas especies seleccionan sitios con componentes estructurales similares de la vegetación. Otros modelos mostraron un soporte bajo, tales como aquellos donde la presencia de *C. rubra* está ligada a otros depredadores y a la presencia humana. La especie fue principalmente registrada como individuos solitarios y mostró actividad más

frecuente en la mañana y tarde. La presencia de crías y jóvenes sugiere que hay condiciones adecuadas para el establecimiento de una población reproductiva de esta especie en la región. Los Chimalapas aún tiene conexión con áreas conservadas (i.e., Reserva de la Biosfera Selva El Ocote) y altamente deforestadas (i.e., Uxpanapa), y debe ser una región prioritaria para la conservación del *C. rubra*.

INTRODUCTION

The Great Curassow (*Crax rubra*) is a large species (4.6 kg), belonging to the family Cracidae. Its distribution ranges from northeastern Mexico to western Ecuador (Vaurie 1968). This species inhabits rain forests, the semi-deciduous and deciduous forests, from lowlands to 1200 m a.s.l., but occasionally occurs as high as 2000 m a.s.l. (Vaurie 1968, Lopez et al. 2014). *Crax rubra* is mostly terrestrial, although it can use other forest strata, using the forest floor to search for seeds, fruit, or drinking (Leopold 2000, López et al. 2014). This species is usually found in groups from 2 to 20 individuals (López et al. 2014).

The ecological importance of *C. rubra* lies in its keystone role for the regeneration of forests through seed dispersal and predation of several plant species. It consumes 74 species, principally their fruits (López et al. 2014). It eats also foliage, flowers, invertebrates, and vertebrates (González-García et al. 2001, López et al. 2014). Species of the genus *Crax* are part of the diet of predators, such as jaguar (*Panthera onca*; Seymour 1989, Estrada 2008), cougar (*Puma concolor*; Estrada 2008), and ocelot (*Leopardus pardalis*; Ludlow & Sunquist 1987). They also represent an important protein source for the local populations of forest-dwelling humans in Mexico and Latin America, contributing importantly to the biomass of total prey taken (González-García et al. 2001, Brooks & Strahl 2000).

Due to over-hunting and habitat loss and fragmentation, *C. rubra* is at risk and its historical distribution is fragmented and reduced, becoming rare or locally extinct throughout of its range (BirdLife International 2016). It has been classified as globally Vulnerable species (BirdLife International 2016), and in Mexico, this species is considered Threatened (González-García et al. 2001, SEMARNAT 2010). Viable populations are expected to occur mostly in protected areas or those with sufficient tree cover in southeastern Mexico, particularly in Los Chimalapas region, but this has not yet been verified (González-García et al. 2001, BirdLife International 2016).

Los Chimalapas region is one of the few relatively extensive tropical rain forests remaining in the country, harboring 464 species of birds, including six species of Cracidae: Plain Chachalaca (*Ortalis vetula*), West Mexican Chachalaca (*Ortalis poliocephala*), Highland Guan (*Penelopina nigra*), Crested Guan (*Penelope purpurascens*), Horned Guan (*Oreophasis derbianus*), and *C. rubra* (Peterson et al. 2003). It is considered a priority region for conservation due to species richness (Peterson et al. 2003, Ortega del Valle et al. 2012). However, this region is not included in any governmental conservation scheme and shows increases in the rate of land use change (Ortega del Valle et al. 2012). There is little information available on *C. rubra* in the region, and its conservation status or basic ecology are unclear in Los Chimalapas.

The information on *C. rubra* ecology in dense tropical forests may contribute to define effective conservation strategies and protocols. The action plan for the conservation of this species require of information on effects of habitat disturbance, hunting pressure, habitat requirements, and population status (Brooks & Strahl 2000). However, it is sometimes quite difficult to assess their population status through abundance estimations. In contrast, other estimates are more feasible, such as occupancy. Occupancy is the proportion of sites or sampling unit occupied by a species. Occupancy is a population parameter that may be useful in conservation strategies, and tends to require less sampling effort than the estimation of abundance. Occupancy models estimate the detection (the probability that at least one individual of a species will be detected, given that the species inhabits the area of interest) and occupancy (the probability that a randomly selected site or sampling unit contains at least one individual of the species) probabilities (Mackenzie et al. 2006). These probabilities can be modeled as a function of habitat characteristics. For example, the local distribution and abundance of cracids depend on hunting pressure, habitat quality, seasonality of key resources, or human presence (Kattan et al. 2016, Martínez-Morales 1999). The risk of predation may also influence their local distribution (López et al. 2014).

Line transects and point counts to detect visual records, vocalizations, or direct capture of individuals are some techniques available to study *C. rubra*. However, line-transect visual surveys sample only small areas and individuals sometimes are difficult to locate in the understory due to the limited visibility inside the forest (Jiménez et al. 2003, Suwanrat et al. 2015). Due to this, there is little information relating to *C. rubra* in the understory. However, researches have demonstrated that camera traps may be a useful tool to obtain information and monitoring cracids and other galliforms in the understory of rain forests. Camera traps have been used to conduct bird inventories (Sáenz et al. 2005) and ecological studies of cracids (Srbek-Araujo et al. 2012, Fernández-Duque et al. 2013, Alves et al. 2015), tinamous (Kuhnen et al. 2012), and pigeons (Martínez-Gómez et al. 2013).

Our aim was to document the occupancy of *C. rubra* in the understory of a rain forest in Los Chimalapas region using camera traps. We expected that species occupancy would be higher in optimal sites
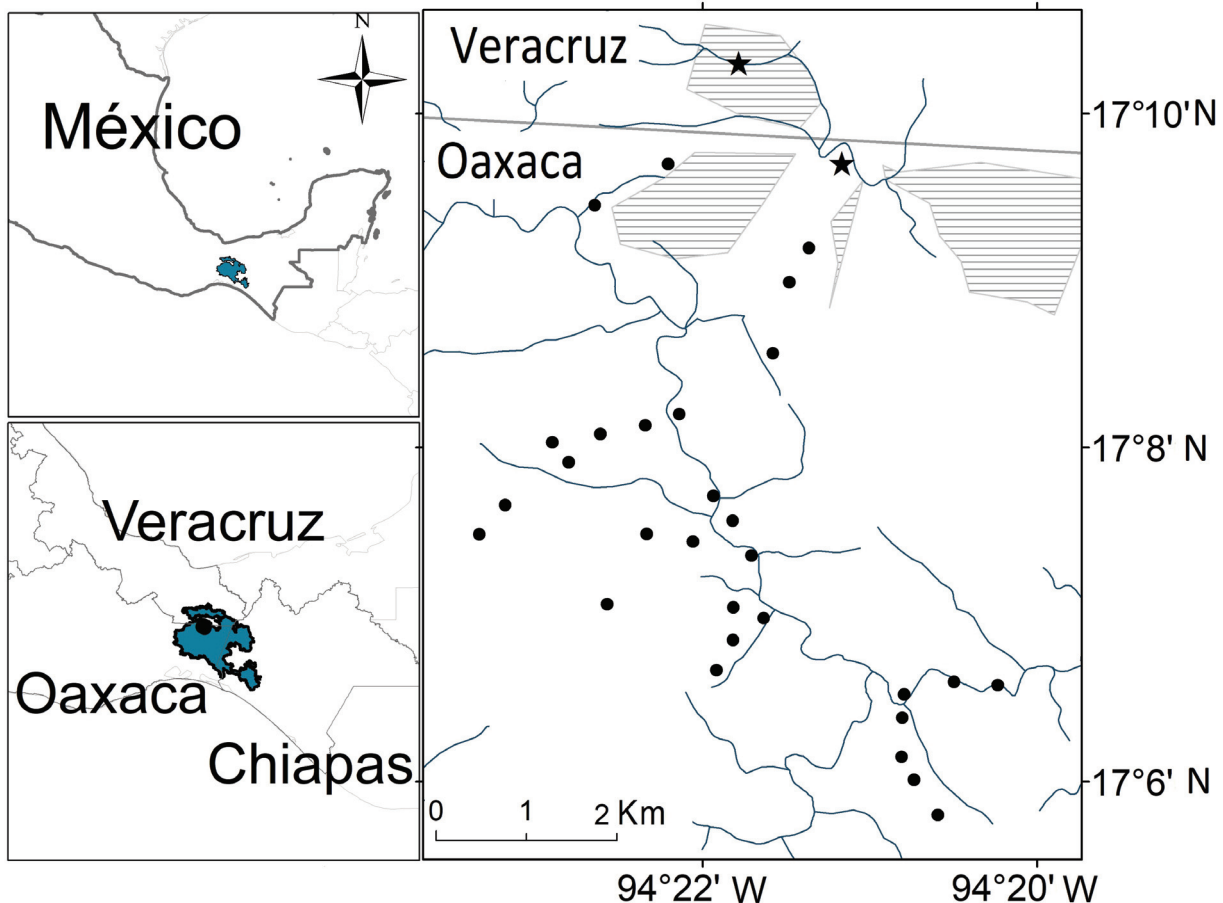
Figure 1. Sampling sites of the Great Curassow (*Crax rubra*) at Los Chimalapas region, southeastern Mexico. Points show the location of the camera traps (2011–2013), stars show the location of villages, and gray lines show the rivers. Hatched polygons depict pasture areas, and the straight gray line at the top of the right panel shows the limit between the states of Oaxaca and Veracruz. The gray area in the insets shows the Selva Zoque-La Sepultura Priority Terrestrial Region in Oaxaca, Veracruz, and Chiapas.

(i.e., those located far from human activities and with lower records of predators) than in more disturbed and predation-vulnerable sites. We also present information on of relative abundance and activity patterns, as well as its variation between the dry and rainy seasons.

METHODS

Study area. Los Chimalapas region is part of the Selva Zoque, a priority region for conservation located in the Mexican states of Oaxaca, Veracruz, and Chiapas, in southeastern Mexico (Figure 1). The area presents contrasting environmental conditions: the topography is irregular with elevations that range from 100 to 2550 m a.s.l., and the vegetation types include tropical rain forest, temperate forest, cloud forest and deciduous forest. The tropical rain forest covers more than 64% of the area (Ortega del Valle et al. 2012). The climate is warm-humid with an average annual temperature of 22–26°C, and an average annual precipitation of 2000–2500 mm (Trejo 2004). Although there is rainfall throughout the year, maximum rainfall occurs from June to December. Our

study site was located in the north of Los Chimalapas region (Figure 1), and the vegetation type is tropical rain forest, with elevations that range from 100 to 800 m a.s.l.

Sampling design. We deployed 29 permanent sampling stations (camera traps) from March 2011 to June 2013. The polygon drawn by the location of the most external camera traps covered an area of 22 km². Because of the rugged topography of Los Chimalapas, we spaced the traps from 0.5 to 1.5 km apart and at an altitudinal range from 100 to 700 m a.s.l. We placed the camera traps 30 cm above the ground. All camera traps remained active in a 24/7 mode and the delay period between photographs was set from 3 seconds to 1 minute, depending on model. We placed four camera traps on trails, five in areas that were close to pasture, and 20 inside the forest. Camera traps used were Wildgame IR4 Digital Game Scouting Camera, ScoutGuard SG550/SG550V, and Bushnell Trophy Cam.

Occupancy models. Although it has been shown that an interval of one hour is adequate to achieve inde-

pendence of photographic records in studies using camera traps to detect mammals, there are a few studies that have assessed the independence of data in the case of birds (Hamel et al. 2013). So, in order to ensure that all events were independent and to avoid pseudoreplication, we grouped the photographic records in 30, 60, 90, 120, 150, 180, 210, 240, 270, and 300 min intervals to quantify temporal autocorrelation by estimating the autocorrelation coefficient, called rk, implemented in the NSSC software, version 2007 (Hintze 2010). It ranges between +1 and −1, where 0 indicates no autocorrelation between samples. Based on the results of these analyses we selected the shortest time interval in which the data were not autocorrelated. Once we selected the appropriate time interval, we considered all photographs for each species taken by each sampling station within this interval as a one single record.

We used occupancy models to analyze the effect human impact and habitat characteristics on the detection (p) and occupancy (ψ) probabilities of *C. rubra* (Mackenzie et al. 2006). Human impact included two variables: the number of photographic records where a human was present (denoted as "human," records ranged from 0 to 83, mean = 3.62, SD = 15.37), and the distance between the camera traps and the nearest village (denoted as "village," distance ranged from 0.3 to 8.2 km). We estimated these values with the ArcGis software, version 9.3 (Esri 2008). Habitat characteristics included altitude ("altitude"), distance to the nearest body of water ("water"), and the presence of potential predators. In the region there are four predators: jaguar, cougar, ocelot, and margay (*Leopardus wiedii*), and their records obtained by the camera traps were used: "jaguar" (0 to 8 records, mean = 1.37, SD = 2.36), "cougar" (0 to 10 records, mean = 1.37, SD = 2.06), "ocelot" (records ranged from 0 to 21, mean = 3.6, SD = 5.46), and "margay" (records ranged from 0 to 27, mean = 2.72, SD = 5.45). We built 17 models: a null model (with constant p and ψ, ψp), eight models with constant p and variable ψ, and eight models with constant ψ and variable p (Table 1).

We standardized all variables by subtracting the mean and dividing by its standard deviation. We used the Presence software, version 11.5 for the construction and evaluation of models (Hines 2006), and selected the best candidate model according to the Akaike Information Criterion modified for small samples (AICc; Burnham & Anderson 2004).

Since occupancy models assume that sites are independent, we applied a preliminary test to assess dependence among sampling sites by the Moran Index (*I*) (Sokal & Oden 1978), implemented in ArcGIS software, version 9.3 (Esri 2008). Values close to zero indicate absence of spatial autocorrelation, and values close to -1 or +1 indicate negative or positive autocorrelation, respectively.

Relative abundance. We defined relative abundance (RA) as the number of independent records during 100 days-trap and compared the relative abundance between the dry (January to May) and rainy (June to December) seasons with the Mann-Whitney *U* test. This test does not require a normal distribution (Zar 1999).

In order to presented information about the population in the region, other characteristics were recorded, such as the presence of offspring and young animals, or the presence of morph types (barred or dark morph). We defined chicks as those light colored individuals with spots or stripes, and juveniles as adult-like adults, but smaller in size with un-developed knob (Sutton 1955, Howell & Webb 1995, Leopold 2000). *Crax rubra* is sexually dimorphic. The coloration of the adult females is extremely variable and presents three color phases: dark phase (the mantle is black or blackish with vague spots or irregular bars), red phase (the mantle is reddish, dark reddish or orange-chestnut, with white striper or blackish spotted), and barred phase (black and white stripes on the head, wings, and tail). The coloration of the adult males is black with a white under-belly, and presents a very conspicuous yellow knob (Vaurie 1968). The difference between the sexes is detectable on the pictures from camera traps.

Activity pattern. In order to analyze the daily activity pattern, we divided the 24 hours period into hour-long segments and classified each independent record within those intervals. We defined maximum activity as the time of the day when more records were obtained, irrespective of the specific activity performed by the individual. To avoid overestimating activity record in the case of groups of individuals, we considered the group as a single record. We compared the daily activity pattern between seasons (dry and rainy) with the non-parametric Watson U^2 test, which is adequate for samples of circular data, such as time (Zar 1999). We also compared the activity patterns between females and males. Statistical tests were performed with the software Oriana version 4 (Kovach Computing Services 2011), and the statistical significance level of all tests was $P \leq 0.05$.

RESULTS

Our results showed that time intervals ≤ 60 min between photographic records were significantly autocorrelated (both $P < 0.05$), whereas longer intervals were not autocorrelated (all $P > 0.05$). We used the time interval of 90 min to define independence of photographic records. Following this criterion, we obtained 376 independent records for *C. rubra*, with an effort of 8529 trapping nights.

Occupancy models. Since camera-trap records were not spatially independent ($I = 0.36$, $P = 0.02$), we eliminated the data from camera traps located at distances less than 600 m. So, we used the data of 27 independent sites ($I = 0.22$, $P = 0.07$). We did not analyze two out of 17 potential models due to the rela-

Table 1. Comparison of linear models analyzing patterns of occupancy of the Great Curassow (*Crax rubra*) detected with camera traps at Los Chimalapas region, Mexico. Akaike Information Criterion (AICc), difference in AICc value between each model and the best model (delta AICc), model weight, and the coefficient and Coefficient of the variable (Beta) with standard error (SE) were included for each model.

Model	AICc[a]	delta AICc[b]	AICc weight	Beta (SE)[c]
ψp_{margay}	472.56	0	0.99	0.75 (0.09)*
$\psi p_{altitude}$	520.17	47.61	0.0001	0.60 (0.11)*
ψp_{water}	528.76	56.2	0.0001	0.48 (0.11)*
ψp_{cougar}	538.46	65.9	<0.0001	0.26 (0.09)*
$\psi_{altitude} p$	541.89	65.90	<0.0001	1.78 (1.39)
ψp	544.10	71.53	<0.0001	
$\psi p_{village}$	543.29	70.73	<0.0001	0.16 (0.12)
ψp_{human}	543.62	71.06	<0.0001	-0.17 (0.15)
ψp_{jaguar}	543.97	71.41	<0.0001	0.30 (0.26)
ψp_{ocelot}	544.21	71.65	<0.0001	0.10 (0.10)
$\psi_{cougar} p$	544.57	72.01	<0.0001	0.96 (1.49)
$\psi_{village} p$	544.87	72.31	<0.0001	-0.48 (0.81)
$\psi_{ocelot} p$	545.01	72.45	<0.0001	0.44 (1.02)
$\psi_{margay} p$	545.11	72.55	<0.0001	0.38 (1.21)
$\psi_{human} p$	545.11	72.55	<0.0001	0.51 (2.12)

tively few records: $\psi_{water} p$ and $\psi_{jaguar} p$. The occupancy model with the highest support was the model ψp_{margay}, and the coefficient for this variable was statistically significant: the detection probability of *C. rubra* was highest at stations where *L. wiedii* presented more records (AIC weight = 0.99, Table 1). Other models had lower support (Table 1). The occupancy probability of *C. rubra* was 0.94 (SE = 0.06), and the detection probability ranged from 0.08 (station with zero records of *L. wiedii*; SE = 0.01) to 0.79 (stations with 27 records of *L. wiedii*; SE = 0.07).

Relative abundance. The relative abundance of *C. rubra* was 4.4 records/100 days-trap. We tested the abundance in each season (dry or wet) of the first year against that of the second year, and we did not detect differences between years for each season ($U_{dry\ season\ 2012\text{-}2013}$ = 11, *P* = 0.75; $U_{wet\ season\ 2011\text{-}2012}$ = 13.5, *P* = 0.15). Thus, we grouped the data for further analyses, and we did not detect differences in abundance between dry and wet season (*U* = 52, *P* = 0.17). Females comprised 35% (N = 142) of all records, 61% were males (N = 199), and 4% were mixed sex groups (N = 35). Small groups of 2 to 4 individuals (mean = 2.26, SD = 0.54) were observed in 26% of records (N = 98), and the remaining were solitary (73%, N = 278). The groups were composed of females, females and

males, females with their chicks, or females with juveniles. Females with one or two chicks were recorded in first half of July 2011 and June 2012, and females with one or two juveniles from May to August (N = 16). We did not observe males near the females with chicks or juveniles. Three records of female *C. rubra* corresponded to the barred morph and the rest to the dark morph.

Activity pattern. Because within each season (dry or wet) the differences in activity pattern between years were not significant (Watson U^2 $test_{dry\ season\ 2012\text{-}2013}$ = 0.13, *P* = 0.1; $U^2_{wet\ season\ 2011\text{-}2012}$ = 0.12, *P* = 0.2)*,* we pooled all data for further analyses. We did not find significant differences in daily activity patterns between seasons (U^2 = 0.07, *P* > 0.5) or between females and males (U^2 = 0.07, *P* = 0.2). Most (93%) records occurred between 06:00–17:00 h Central Standard Time (CST; Figure 2).

DISCUSSION

In our study, the population of *C. rubra* showed consistence with previous studies: activity was higher in the morning and in the afternoon, chicks and juveniles were observed from July to August, and solitary individuals were observed more frequently. We
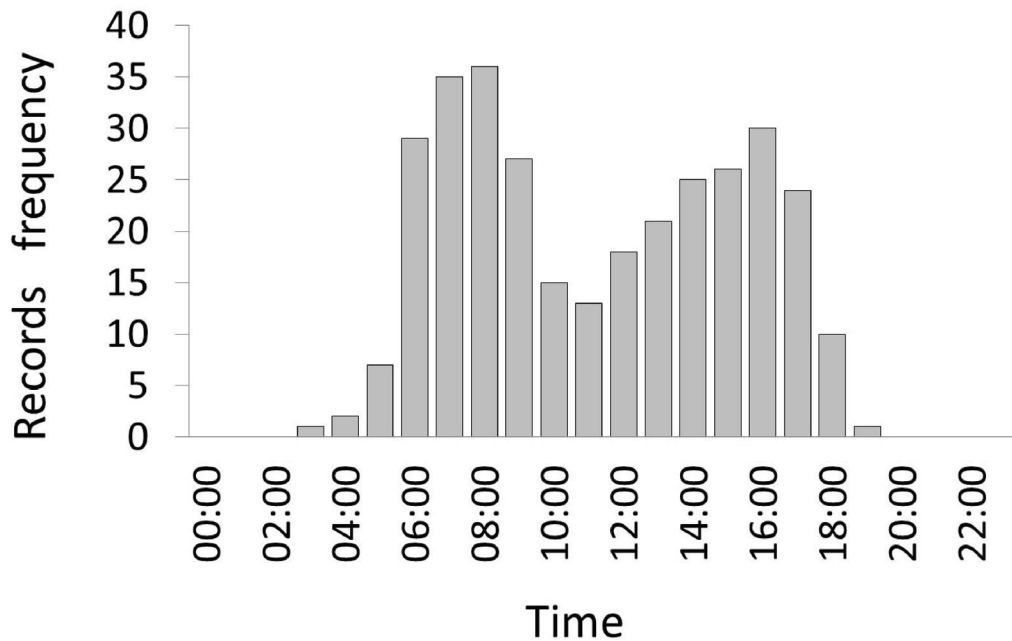
Figure 2. Daily activity pattern of Great Curassow (*Crax rubra*) at Los Chimalapas region, southeastern Mexico (2011–2013). The gray bars show the number of records in each hour.

recorded that detection and occupancy probability were not related to larger predators or human presence. Contrary to expectations, we found a positive relationship between detection probability of *C. rubra* and *L. wiedii*, a potential predator. Two hypotheses may explain this result: predation or similarity in habitat use.

The diet of *L. wiedii* includes rodents, small mammals, and birds (Sunquist & Sunquist 2002). Although the consumption of *C. rubra* by *L. wiedii* has not been recorded, tinamous, chachalacas, and chickens form part of its diet (de Oliveira 1998, Bianchi et al. 2011, Cinta-Magallón et al. 2012), and in some cases birds have been found to be the most consumed prey items (Sunquist & Sunquists 2002, Bianchi et al. 2011, Cinta-Magallón et al. 2012, Seibert et al. 2015). Hence, the similar pattern of occupancy between these species may indicate that *L. wiedii* is tracking the abundance of its potential prey, *C. rubra*.

Alternatively, both *L. wiedii* and *C. rubra* may use sites with similar structural components of vegetation. Both species are strongly associated to forest habitat with dense canopy cover, and are adapted to arboreal life using trees as refuges and resting places. Both species move frequently on the ground and the forest canopy (de Oliveira 1998, Hodge 2014, Lopez et al. 2014). They also face similar risks. Deforestation, habitat fragmentation, and poaching are threats affecting their populations (Sunquist & Sunquist 2002, Lopez et al. 2014).

We hypothesized that the distribution and abundance of *C. rubra* would correlate with habitat productivity, availability of freshwater, human settlements, and hunting pressure (Martínez-Morales 1999, Kattan et al. 2016). However, we fund no sup-

port for these predictions as there were no significant effects of human presence, proximity to the nearest village, or presence of larger predators. In Los Chimalapas region, habitat disturbance is still low and there are large areas of well-preserved tropical rain forest. Rainfall occurs throughout the year, there are several permanent water bodies, and a variety of perennial trees (Ortega del Valle et al. 2012). The presence of other prey of larger predators (e.g., paca *Cuniculus paca* and agouti *Dasyprocta mexicana*) may reduce predation pressure on *C. rubra*, accounting for the lack of correlation between occupancy and detection probabilities of *C. rubra* and these predators. Other factors not included in our analysis might explain the presence of *C. rubra* in the understory of Los Chimalapas rain forest, such as canopy cover or density of fruit.

We did not find significant differences in neither daily activity patterns nor relative abundance between seasons. The lack of effect is most likely due to the lack of extreme seasonal fluctuations which is typical of the tropical semi-deciduous forest. Possibly, the availability of important resources (e.g., fruit, leaves, water) does not vary substantially throughout the year in the region.

In Los Chimalapas, 70% of records were solitary individuals and the observed groups were small. Our results were consistent with those observed in other areas in Mexico and Costa Rica, where solitary individuals or small groups were observed (Lafleur et al. 2014, Lopez et al. 2014), and with other species of curassow, such as Bare-faced Curassow (*C. fasciolata*) in Argentina (Fernández-Duque et al. 2013) and Red-Billed Curassow (*C. blumenbachii*) in Brazil (Srbek-Araujo et al. 2012).

Our data reveal that males and females of *C. rubra* were recorded at different rates in the understory. Males were recorded more often than females, but this may not represent the sex ratio in the population. Female curassows may spend more time in the upper stratum of the forest because they incubate and take care of chicks (González-García et al. 2001), and this behavioral difference may have caused a bias towards detecting more males in the understory. This has been suggested in a previous study, where individual males of *C. blumenbachii* were recorded more often than females by camera traps in the Atlantic Forest, Brazil (Srbek-Araujo et al. 2012). We think that additional studies are required to assess the factors that affect the probability of detection by sex using camera traps in the study area.

We obtained more records of *C. rubra* in the morning and afternoon than at other day times. Our results were consistent with previous studies: activity of *C. rubra* and other curassows is higher in the morning and in the afternoon, and decreases in hours of higher temperature, e.g., during mid-day (Srbeck-Araujo et al. 2012, Fernández-Duque et al. 2013, Lafleur et al. 2014). Males and females of *C. rubra* had similar activity patterns, as has been observed in *C. blumenbachii* activity by camera traps (Srbeck-Araujo et al. 2012).

The presence of chicks and juveniles suggests that the conditions are suitable for the reproduction of this species in Los Chimalapas. The timing of breeding season was similar to other regions: *C. rubra* breeds from February to June, with chicks observed from April to October, in Mexico (Leopold 2000, López et al. 2014), and in June in Costa Rica (Lafleur et al. 2014).

In some regions near to Los Chimalapas, suitable habitats are currently reduced and isolated by pastures and other anthropogenic land uses (González-García et al. 2001, Lopez et al. 2014). Los Chimalapas still has connections with both conserved (i.e., Selva El Ocote Biosphere Reserve) and highly deforested areas (i.e., the Uxpanapa region), and it may function as an important region for *C. rubra* conservation that links different environments with varying levels of human impact. However, an increase in human land use and fragmentation may jeopardize the prevalence of this species in the region.

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