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# CONSERVATION STATUS AND HABITAT PREFERENCES OF THE COZUMEL CURASSOW[1]

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*Abstract.* I assessed the population status and habitat preferences of the Cozumel Curassow, *Crax rubra griscomi,* in the forests of Cozumel Island, Mexico, from October 1994 to June 1995. The estimated density was 0.9 curassows km$^{-2}$ with a population size of about 300 birds. These numbers and the fact that the Cozumel Curassow is restricted to the island, place this endemic cracid within the conservation status of Critically Endangered. Hunting is likely the main cause of its present conservation status. This curassow showed a greater preference for the tropical semi-deciduous forest than for the low tropical deciduous forest. Likewise, older stands of forest have a positive influence on its distribution. Freshwater sources within the forests have a positive influence on the Cozumel Curassow distribution within a radius of about 2 km. Human settlements and human accesses to the forest interior showed a negative influence on its distribution within a radius of 4.5 km.

*Key words: conservation, Cozumel Curassow, Cracidae,* Crax rubra griscomi, *density, hunting, Yucatán Peninsula.*

*Resumen.* Evalué el estado poblacional y las preferencias de hábitat del hocofaisán de Cozumel, *Crax rubra griscomi,* en las selvas de la Isla de Cozumel, México, de octubre de 1994 a junio de 1995. La densidad estimada fue de 0.9 individuos km$^{-2}$ y el tamaño poblacional de aproximadamente 300 individuos. Estas estimaciones y el hecho de que el hocofaisán de Cozumel esté restringido a la isla, colocan a este crácido en un estado de conservación definido como en Crítico Peligro de Extinción. Es probable que la cacería sea la causa principal de su actual estado de conservación. Este crácido mostró una mayor preferencia por la selva mediana subcaducifolia que por la selva baja caducifolia. Asimismo, las zonas de selva con los árboles más viejos tuvieron una influencia positiva en la distribución de *C. r. griscomi.* Los *cenotes* y las *aguadas* del interior de las selvas, tuvieron una influencia positiva en la distribución del hocofaisán de Cozumel, dentro de un radio de aproximadamente 2 km. Los asentamientos humanos y los accesos hacia el interior de la selva mostraron una influencia negativa en la distribución de este crácido dentro de un margen de aproximadamente 4.5 km.

## INTRODUCTION

Nelson (1926) was the first to comment on the relative abundance of the Cozumel Curassow, *Crax rubra griscomi,* stating that "this curassow was common," when he and Goldman collected some specimens in Cozumel Island, in 1901. By the late 1940s, however, this endemic cracid was considered almost extinct (Paynter 1955), and by the late 1960s as a possibly extinct subspecies (Delacour and Amadon 1973). Although scanty records of curassows documented the survival of this cracid (King 1981, Miranda et al. 1988), its conservation status remained unclear, even until 1995 (Hoyo et al. 1994, Howell and Webb 1995).

In this paper, I document the conservation status of the Cozumel Curassow through the analysis of its density and population size. I also relate different density estimates and abundances with habitat characteristics to show habitat preferences of this endemic cracid.

## METHODS

### STUDY AREA

Cozumel Island is located 17.5 km off the northeastern coast of the Yucatán Peninsula, on the Mexican Caribbean Sea. The island is a coralline limestone block of 486 km$^2$ (not including inland seasonal lagoons), and more than 75% of the island's surface is forested. The main vegetation types are tropical semi-deciduous forest, low tropical deciduous forest, and mangrove for-

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est. The island is periodically struck by hurricanes, which are probably one of the most important ecological factors affecting the structure and composition of the forests. Cozumel Island hosts four endemic bird species and 15 endemic subspecies, including the Cozumel Curassow (Howell and Webb 1995).

## ABUNDANCE AND DISTRIBUTION

Field work was carried out in the forests of Cozumel Island from October 1994 to June 1995. I used line transect sampling to estimate density and population size. Sampling covered 386 km along transects (367 km in the tropical semi-deciduous forest and 19 km in the low tropical deciduous forest). I surveyed 10 line-transects measuring from 2.1 to 5.8 km. Time of survey ranged from 04:30 to 19:30 (average 07:00–16:00), on 15 days each month.

For each curassow detected, I recorded sex, age (in males), social status, and the perpendicular distance to the line transect to estimate density. The exact position of the bird along the transect also was recorded to relate its location with habitat characteristics. Density and population size estimations (mean ± SE) were based upon distance sampling theory (Buckland et al. 1993), and calculations were done with the program DISTANCE V2.2 (Laake et al. 1994).

To evaluate the influence of *cenotes* (sinkholes that have a ground water fed pool at the bottom) and *aguadas* (pot holes that temporarily retain rainwater) on the abundance and distribution of the Cozumel Curassow, I estimated cumulative densities for the areas within different radial distances from those water sources, and compared those densities with the cumulative densities for the areas away from each of those radial distances. The density estimates were plotted and curve fitted by polynomial regression analysis to explore the effect of those landscape features on the Cozumel Curassow.

Density estimates of the Cozumel Curassow at different linear distances from human settlements and human accesses to the forest interior were used to evaluate their effect on the abundance and distribution of this cracid. Linear distances were considered because the only way humans can move through the forests is by trails, because of dense understory vegetation. The densities estimated were plotted and curve fitted by polynomial regression analysis to examine the effect of human influence on this cracid.

To analyze vegetation characteristics of the forest tracts along the transects, I surveyed 141 plots (200 × 40 m) along eight of the transects. In each plot, I recorded the abundance of the tree species *Brosimum alicastrum, Manilkara zapota,* and *Mastichodendron foetidissimum,* with diameter at breast height (dbh) ≥ 16 cm. These tree species were selected because of their importance as food resources for the Great Curassow, *C. r. rubra* (Sermeño-Martínez 1986, Jorgenson 1993), and also because *M. zapota* and *M. foetidissimum* are two of the dominant tree species in the forests of the island. To assess the influence of these tree species on the abundance and distribution of the Cozumel Curassow, I compared the abundances of the tree species in plots where this cracid was detected and those where it was not detected. Statistical comparisons were made with the Mann-Whitney *U*-test corrected for ties (Sokal and Rohlf 1995). To avoid any bias caused by the association curassow-*cenote,* I eliminated from the analysis the plots within a radius of 250 m from a *cenote.*

## RESULTS

Seventeen visual and vocal encounters of Cozumel Curassows were recorded from January to June. The observations included nine male and eight female detections. All detections occurred in the tropical semi-deciduous forest, and none in the low tropical deciduous forest, although this cracid also inhabits this vegetation type according to local informants. The lack of detections in this forest type is likely related to the difference in sampling effort between the two forest types, and also probably with the difference in their ecological importance for this cracid, as well as the degree of human influence (see below).

The estimated density of the Cozumel Curassow in the forests of the island was 0.9 ± 0.3 birds $km^{-2}$. Considering the estimated population density and the 349 $km^2$ of forests on Cozumel Island, which represents the main potential suitable habitat for the Cozumel Curassow, I estimated a population of 304 ± 97.6 curassows inhabiting the island, with the tropical semi-deciduous forest supporting most of the population (262 ± 84.6 curassows). Based upon the birds detected, the sex ratio of the Cozumel Curassow population can be inferred to be close to 1:1.

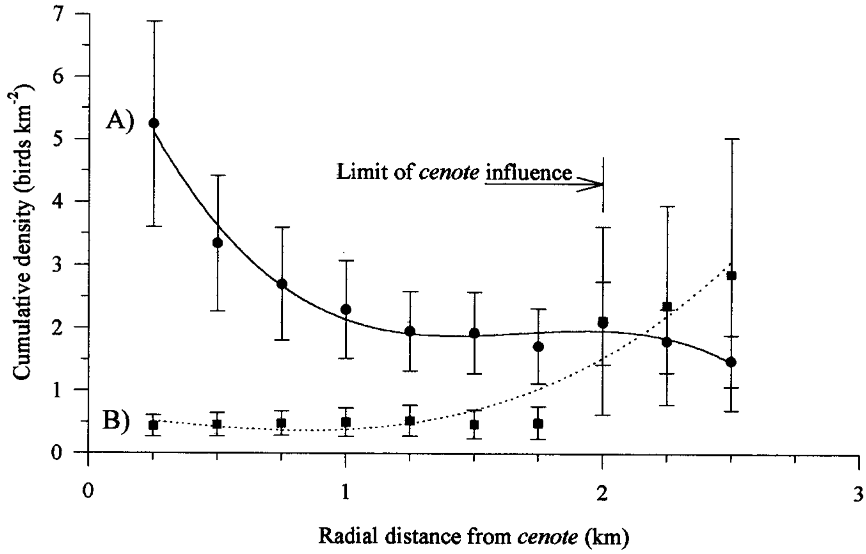


FIGURE 1. Influence of *cenotes* on Cozumel Curassow density. (A) Circles (with standard error bars) represent the cumulative density at different radial distances from *cenotes*. The continuous line defines the best curve fitted for this cumulative density ($R^2$ = 0.98, $P$ < 0.001). (B) Squares (with standard error bars) represent the cumulative density away from a given radial distance from *cenotes*. The dotted line defines the best curve fitted for this cumulative density ($R^2$ = 0.91, $P$ < 0.002).

Using only the age of males (because it is not possible to identify a female's age from sightings in the field), I estimated that the Cozumel Curassow population averages 253 ± 81.4 adults and 51 ± 16.3 subadults (≤ 1 year old).

Because detections of the Cozumel Curassow occurred mainly during the dry season, the results obtained here clearly show the *cenotes* and *aguadas* influence on its distribution. The highest densities of this endemic cracid were found near these water sources, and they decreased markedly farther from them (Fig. 1A). When comparing these densities with densities away from a given distance from the *cenotes* and *aguadas* (Fig. 1B), striking differences are noted, but these differences are absent at about 2 km from the *cenotes* and *aguadas*. This suggests that the *cenotes* and *aguadas* influence on the Cozumel Curassow density is within 2 km of the radial distance from those water sources.

Almost 60% of all curassows detected were found within 250 m of *cenotes* and *aguadas*. This clustering is more evident when considering the sampling effort (36 km surveyed near and 350 km far from *cenotes* and *aguadas*). Significantly more curassows were detected near *cenotes* and *aguadas* ($G_{adj}$ = 25.0, df = 1, $P$ < 0.001) than far from them.

Human settlements (urban and rural), human accesses to the forest interior (roads and trails), and human activities within the forests (hunting, wood gathering) were found to have a negative effect on the Cozumel Curassow abundance and distribution. Based upon cumulative densities, three levels of human influence on the Cozumel Curassow population were identified (Fig. 2). The first occurs between 0 to 1.5 km from human settlements and accesses, where the Cozumel Curassow is absent. The second level arises between distances > 1.5 to 3 km, where the density of this cracid shows a depletion with respect to the overall density. The last level happens after 3 km from human settlements and accesses, where density tends to achieve the value of the overall population density on the island.

The exact detection distances from human settlements and from human accesses to forest trails of all Cozumel Curassow encounters (Fig. 3) suggest that the limit of the highest human influence is located at about 1.9 km, because the nearest detection occurred at that distance. It should be noted that 91% of the detections between distances 3.2 and 4.4 km from human influence were associated with *cenotes* and *aguadas* (Fig. 3). Thus, it can be assumed that the occurrence of the Cozumel Curassow at this dis-

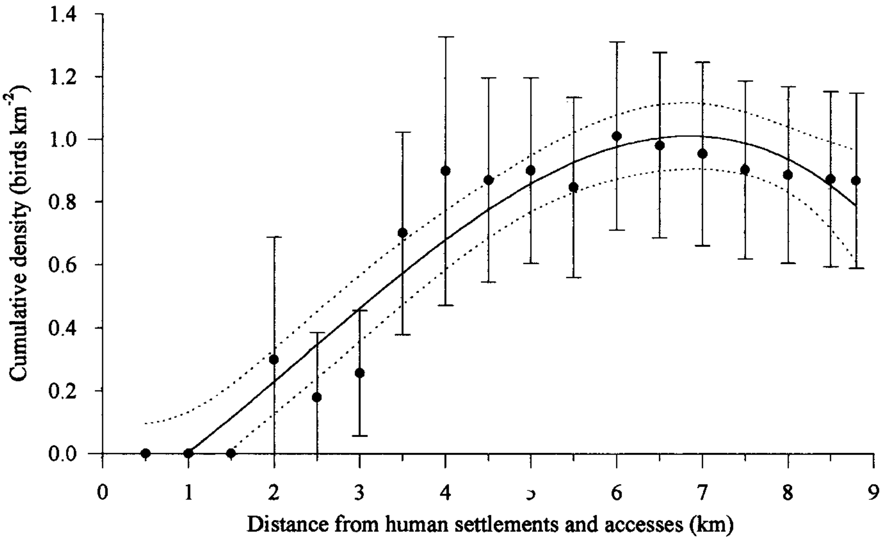


FIGURE 2. Human influence on Cozumel Curassow density. Circles (with standard error bars) represent the cumulative density at different distances from human settlements and human accesses to the forest interior. The continuous line represents the best curve fitted, and the dotted lines define the 95% confidence interval of the cubic polynomial regression curve ($R^2 = 0.92$, $P < 0.001$).

tance interval is influenced by the presence of these water sources, rather than by a decrease in human influence. If we consider only the sightings not associated with *cenotes* and *aguadas*, then the actual decrease in human influence might arise farther than 4.4 km from the sources of human influence (Fig. 3). Female curassows could be considered more sensitive to human influence, because the nearest female was detected at 3.2 km from human influence, whereas the male closest to the sources of human influence was detected at 1.9 km (Fig. 3). There were no

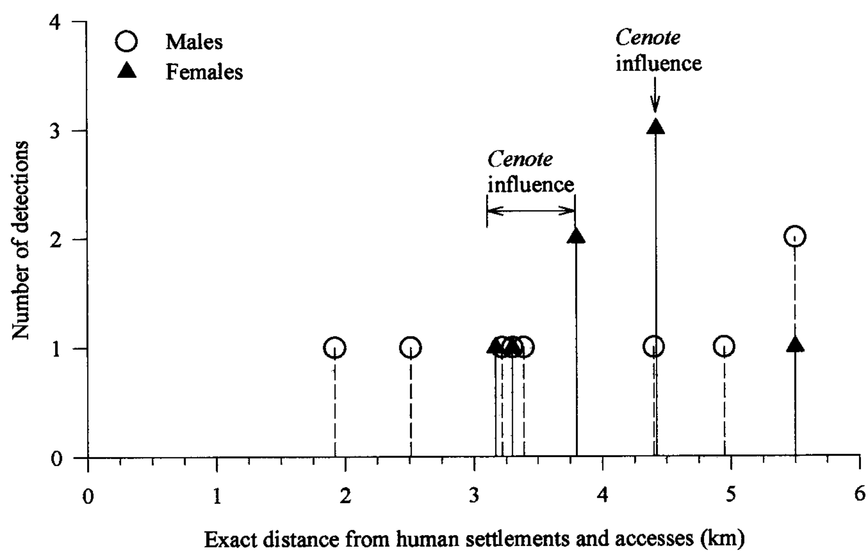


FIGURE 3. Exact distance from human settlements and human accesses to the forest interior of all *Crax rubra griscomi* detections by sex, in the transects surveyed in the forests of Cozumel Island. The areas influenced by the *cenotes* are indicated with the arrows.

differences between sexes farther than 3.2 km from human settlements and accesses.

The tree species that showed a significant influence on the distribution of the Cozumel Curassow were *M. zapota* ($t_{[\infty]} = -3.6$, $n_1 = 124$, $n_2 = 10$, $P < 0.001$) and *M. foetidissimum* ($t_{[\infty]} = -2.3$, $n_1 = 124$, $n_2 = 10$, $P < 0.05$), because the Cozumel Curassow detections tended to be in the plots that held the higher abundances of these tree species. This influence is even more striking when considering only the plots where the older stands (dbh $\geq$ 29 cm) of these species are located ($t_{[\infty]} = -4.1$, $n_1 = 124$, $n_2 = 10$, $P < 0.001$ for *M. zapota,* and $t_{[\infty]} = -2.9$, $n_1 = 124$, $n_2 = 10$, $P < 0.01$ for *M. foetidissimum*). These older stands of forest also are located farther than 3.5 km from human settlements and accesses to the forest interior ($t_{[\infty]} = -4.6$, $n_1 = 78$, $n_2 = 63$, $P < 0.001$).

On the other hand, *B. alicastrum* did not show any relationship with the distribution of the Cozumel Curassow ($t_{[\infty]} = -1.1$, $n_1 = 124$, $n_2 = 10$, $P > 0.2$), regardless of its importance as a food resource. The reason was probably that all detections of this curassow were between January and early June, when this tree is not fruiting on Cozumel Island. Because *B. alicastrum* is closely associated with *cenotes* ($t_{[\infty]} = -4.4$, $n_1 = 130$, $n_2 = 11$, $P < 0.001$), the possible link between the Cozumel Curassow and *B. alicastrum* could have been obscured because the plots close to *cenotes* were eliminated from the analysis to avoid bias caused by the association of curassow-*cenote.*

## DISCUSSION

The Cozumel Curassow's ecological density (density based upon the suitable habitat available) is low if compared with density estimates for other curassow populations in pristine sites, but is similar to the ones reported for hunted localities. Terborgh et al. (1990), using spot-mapping, reported a density of 5 birds km$^{-2}$ for the Razor-billed Curassow, *Mitu tuberosa,* in a mature forest. Thiollay (1989), using strip-transect censuses, estimated a density of 8.4 $\pm$ 1.1 birds km$^{-2}$ for the Black Curassow, *Crax alector,* in an area with no hunting within $\geq$ 50 km, in a continuous primary forest. Silva and Strahl (1991), using the mean perpendicular detection distances from the line transect, estimated a density of 14 birds km$^{-2}$ for the Black Curassow in a primary forest.

Thiollay (1989, 1994) found that the Black Curassow density was reduced to 1.4 $\pm$ 0.9 birds km$^{-2}$ in a forest with the nearest hunting area 3–20 km away, and to 0.4 $\pm$ 0.3 birds km$^{-2}$ in a regularly hunted area. This showed that hunting pressure reduced this curassow density by approximately 70–99%, even in a primary forest. The Cozumel Curassow density is about 10–20% of the estimate for a curassow population in a pristine tropical forest. Considering this evidence, the low density of the Cozumel Curassow is likely influenced by a continuous hunting pressure on the population, probably from the second half of the last century, when the island was again inhabited by humans (Antochiw and Dachary 1991). Thiollay (1989, 1994) stated that the low curassow densities in hunted localities are probably maintained only by the immigration of birds from surrounding areas that are not subjected to hunting. The Cozumel Curassow population, however, is more likely to be reduced even to extinction if hunting continues, because, as an isolated population, there is no buffer effect by immigration, as there can be on the mainland.

Silva and Strahl (1991) attributed the reduction in the Black Curassow density in a primary forest from 10.2 birds km$^{-2}$ to 7.7 birds km$^{-2}$ after a year, to an increase in subsistence hunting pressure, logging exploration, and paving of the access road in that area. Thiollay (1992) also found that the Black Curassow was eliminated in an area of continuous primary forest, because hunting pressure was much aggravated and extended into the forest by logging roads, and also because of the influence of selective logging on forest structure. These circumstances also may be reflected in the present population status of the Cozumel Curassow. From the 1920s to the 1950s, when the latex from *M. zapota* trees was harvested in the forests of the island (Antochiw and Dachary 1991), the creation of tracks in the forest probably increased hunting pressure on the Cozumel Curassow population. By the late 1940s, the population of this cracid was severely reduced (Paynter 1955). Additionally, the construction of paved roads in the 1970s furthered hunting pressure and habitat destruction, as stated by local informants, who said that prior to the 1970s, the Cozumel Curassow was more common on the island than nowadays.

If it is assumed that a relatively "healthy" Cozumel Curassow population should have a density of about 5–8 birds $km^{-2}$, the population size of the Cozumel Curassow on the entire island in pristine conditions, probably was between 1,700 and 3,400 birds. If these numbers are considered as the Cozumel Curassow population size that existed just before human resettlement on the island, the present estimated population size of this endemic cracid probably represents a reduction of about 90%, which coincides with a population reduction as a result of hunting (Thiollay 1989).

According to the results presented here, the conservation status of the Cozumel Curassow is defined as "Critically Endangered," because the population of this cracid fulfills one of the criteria proposed by the IUCN (1994) to be included in this category: the estimated population size held around 250 adult curassows, which are at high risk of being easily reduced because the whole population, consisting of about 300 birds, is located only on Cozumel Island (criterion C2b). Additionally, the population probably has been reduced 90% since the mid-1800s, and it may have suffered some further reduction after the completion of this study due to Hurricane Roxanne hitting the island in October 1995.

*Cenotes* and *aguadas* can be considered as keystone water sources for wildlife throughout the dry season on Cozumel Island, and probably in most of the Yucatán Peninsula, because they represent the only sources of freshwater available during that period, thus their conservation and protection is essential. *Cenotes* are fed by an underground freshwater layer that lies on a salt water layer, and the water wells that provide water for the human population of the island also use that freshwater layer. If water wells for human use are overexploited, the water quality and water level of *cenotes* may be threaten. Thus, a management program which ensures a sustained water quality and water level in *cenotes* is paramount. Additionally, because local hunters know the importance of these water sources for the Cozumel Curassow (and other wildlife species), this cracid is more frequently hunted near the *cenotes* and *aguadas* during the dry season, which also coincides with its reproductive period (February to June). Therefore, it is essential to protect these areas from hunting, because it would diminish hunting pressure on the Cozumel Curassow.

Based on this study, the following bands of human influence on the Cozumel Curassow occurrence and density were detected: (1) 0–1.5 km from human settlements, where the Cozumel Curassow is absent, (2) 1.5–3 km, where density is depleted to about 0.1 to 0.5 birds $km^{-2}$, (3) 3–4.5 km, where the presence of *cenotes* increases density from 0.5 to 0.8 birds $km^{-2}$, and (4) $>$ 4.5 km, where human influence is at its minimum in the island forests. These results may also account for the low density of the Cozumel Curassow detected in the low tropical deciduous forest, because most of this forest type is located within 3 km of human settlements and roads.

The changes on the Cozumel Curassow density with regard to human influence agree with those on the Black Curassow reported by Thiollay (1989) due to hunting. Thus, these findings suggest that human influence (and probably hunting specifically) have had an important adverse effect on the Cozumel Curassow population, and may account, at least partially, for its present conservation status.

The available information on the ecology and biology of the Cozumel Curassow is limited, because this cracid had never been systematically studied in the field. Research is needed to determine the population trends and population structure of this cracid; thus a monitoring program is required to determine changes in population size, density, and structure. Studies on changes in land-use and natural vegetation cover on the island would be of paramount importance because these factors have significant implications for the conservation of Cozumel Island biological diversity.

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