

## SEASONAL ABUNDANCE AND BREEDING CHRONOLOGY OF THE MILITARY MACAW (*ARA MILITARIS*) IN A SEMI-ARID REGION OF CENTRAL MEXICO

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**Resumen.** – Abundancia estacional y cronología reproductiva de la Guacamaya verde (*Ara militaris*) en una región semi-árida del centro de México. – La Guacamaya verde (*Ara militaris*) es una especie amenazada que anida en árboles y acantilados y se distribuye en los bosques húmedos semi-decíduos. Poco se sabe acerca de su ecología en el medio silvestre. Aquí presentamos un análisis de una población que habita una región semiárida en el centro de México y que anida en un acantilado. Encontramos un máximo de 67 individuos que utilizaban como dormitorio y sitio de reproducción en la barranca del Sabino, Santa María Tecomavaca, Oaxaca, México. Las aves fueron más comunes en la barranca de Marzo a Septiembre. El mes con el mayor número promedio de Guacamayas detectadas fue Agosto con 40 individuos. Durante el invierno (Noviembre a Enero), solamente una pareja permaneció en ésta área. La época de reproducción ocurrió entre Marzo y Octubre. La actividad en la barranca se concentró durante las mañanas y tardes. Las salidas durante la mañana fueron más sincrónicas que las llegadas en las tardes. Durante Agosto–Septiembre, cuando se encontraban en etapa de incubación y crianza de pollos, las aves permanecían en la barranca todo el día. Documentamos la presencia de 30 cavidades potenciales y de 5 nidos activos durante el año y observamos a dos volantones producidos durante el año. El éxito reproductivo fue bajo con pocas parejas reproductivas y pocas aves sobrevivientes.

**Abstract.** – The Military Macaw (*Ara militaris*) is a threatened species which frequently nests in trees and cliffs and is considered to inhabit humid semi-deciduous forest, though little is known of the species' ecology in the wild. Here we present data on a cliff-nesting population that inhabits a semi-arid region in central Mexico. We found 67 individuals that were resting and breeding in the Sabino Canyon, Santa Maria Tecomavaca, Oaxaca, Mexico. Macaws were more abundant in the canyon from March to September. The highest average number of birds (40) was during August. During winter (November to January), only one pair remained in the area. The breeding season took place between March and October. In the canyon, activity was greatest during the mornings and evenings with few birds flying during late afternoon. Departures were more concentrated during the morning than arrival in the afternoon. In August–September, when incubation and hatching occurred, birds remained in the canyon during the whole day. We docu-

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mented the presence of 30 potential cavities, and 5 active nests during one year, and observed two flying juveniles produced during the year. The reproductive output was apparently low with few breeding pairs and few surviving young. *Accepted 10 February 2009.*

**Key words:** Military Macaw, *Ara militaris*, breeding chronology, endangered species, Mexico, secondary cavity nesters.

## INTRODUCTION

The Military Macaw (*Ara militaris*) is a vulnerable species that nests in holes of large trees (> 50 cm DBH; Forshaw 1977, del Hoyo *et al.* 1997, Brightsmith 2005a, 2005b, 2005c) and also on cliffs. Its populations have been reduced and distribution is fragmented (del Hoyo *et al.* 1997, Birdlife International 2003). It inhabits tropical semi-deciduous forests along the Pacific and Atlantic slopes through Central and South America (Forshaw 1977, Birdlife International 2003). In recent decades, wild populations of the Military Macaw have become increasingly isolated, and the species is considered vulnerable in the IUCN red-list (Collar & Juniper 1992, Iñigo-Elias 1999, Snyder *et al.* 2000, BirdLife International 2003), being included in Appendix I of CITES, and classified as endangered in México (CITES 1998, SEMARNAT 2002). Major threats to the survival of this species include harvesting of mature trees and pet trade (Iñigo-Elias 1999).

Little information exists on the ecology of Military Macaws in the wild because only a few populations have been studied in Mexico. Each of the four populations of Military Macaws studied in Mexico is estimated to comprise between 30 to 90 individuals that breed and forage in remote areas with difficult access (Carreón 1997, Loza 1997, Gaucín 2000, Gómez-Garduño 2004).

On the Pacific coast of Mexico, the Military Macaw breeds between October and February (Carreón 1997, Loza 1997). However, in the northern part of the species distribution, breeding has been reported in July

(Fleming & Baker 1963). In Jalisco, Military Macaws nest in cavities of large trees, measuring between 0.92 and 1.44 m DBH, and 24 to 28 m in total height (Carreón 1997, Gómez-Garduño 2004). In this colony, 66% of the birds breed. However, in the other studied colony to date (Gaucín 2000) situated in a drier zone of the Sierra Gorda Biosphere Reserve (central Mexico), macaws nested in a cliff. In this population, between 9 and 23% of the birds nested. No data on fledglings were provided in either study.

The purpose of this study was to evaluate the cliff nesting population of Military Macaw inhabiting a dry tropical deciduous forest in the Tecomavaca, Oaxaca, central Mexico. We studied the seasonal abundance, and breeding activities of the species.

## METHODS

*Study site.* We conducted the study in a 250 m deep canyon situated near Santa Maria Tecomavaca, Oaxaca, in the basin of Sabino River (17°57'N, 97°05'W, Fig. 1). The canyon has vertical walls composed of limestone, with the floor at 600 m a.s.l., while the rim reaches 880 m a.s.l. The major vegetation in the area is tropical deciduous forest dominated by *Cyrtocarpa procera*, *Ceiba aesculifolia*, *Jatropha dioica* and several species of *Bursera*, and a columnar cactus *Neobuxbaumia tetetzo* (Valiente-Banuet *et al.* 2000). In another study in the same study site, trees were measured in transects randomly chosen around the canyon (Contreras-González 2007). From 279 trees measured in an area of 0.4 ha, mean DBH was  $16.2 \pm 0.4$  cm (range 5–27 cm). Twenty three plant spe-

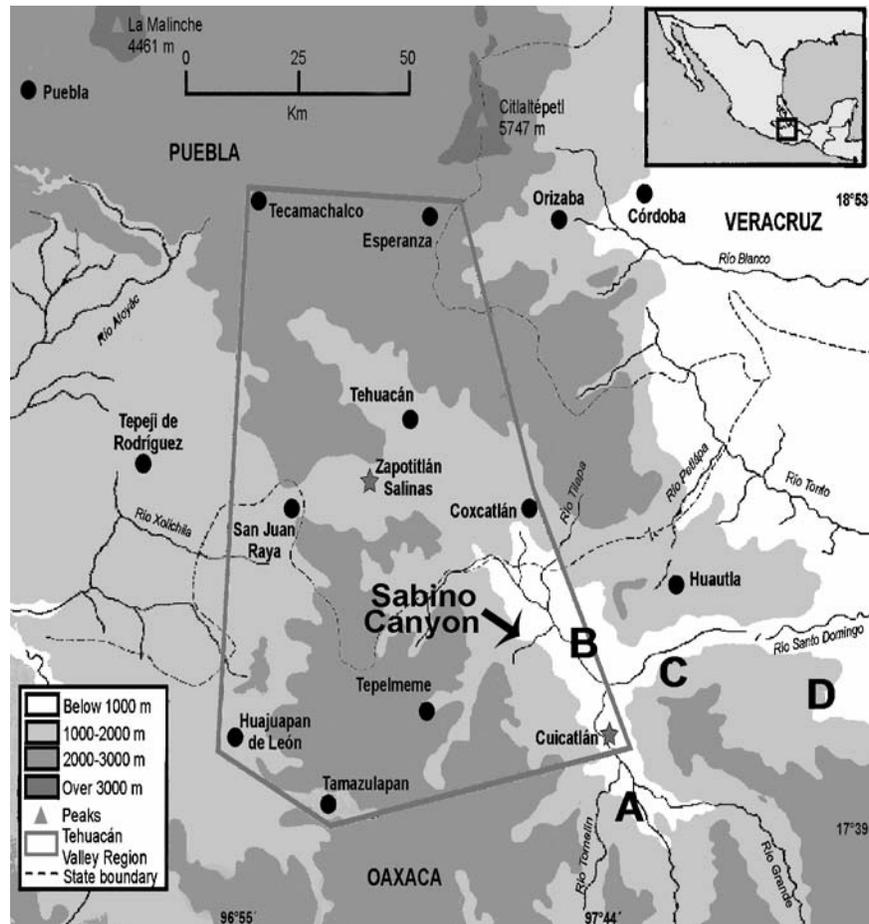


FIG. 1. Study site location. The Sabino Canyon river basin is situated in the southern part of the Tehuacán-Cuicatlán Biosphere Reserve in central México.

cies were registered being the more common (with more than 40 ind/ha) *Neobuxbaumia tetetzo*, *Fouquieria formosa*, *Parkinsonia praecox*, *Bursera morelensis*, and *Jatropha neopaciflora*. The species with higher diameters were *Cyrtocarpa procerca* ( $22.9 \pm 3.06$  cm,  $n = 11$ ), *Pachycereus weberii* ( $22.5 \pm 0.51$  cm,  $n = 2$ ), *Neobuxbaumia tetetzo* ( $20.7 \pm 0.39$  cm,  $n = 109$ ), and *Ceiba aesculifolia* var. *parvifolia* ( $19.5 \pm 3.13$  cm,  $n = 12$ ).

Mean annual temperatures range from 18°C to 33°C. Mean annual rainfall is  $474.7 \pm 20.2$  mm (1961–1995 ; Velazques & Balacan

2000), with a rainy season between June and October, and a dry season from November to May.

*Macaw abundance and activity.* We made monthly visits for 8 days to Sabino Canyon from February 2005 to March 2006 to monitor temporal variation in abundance and activity of Military Macaws.

We conducted surveys during 3 non-consecutive days in each month to determine the number of birds in the area (total census time

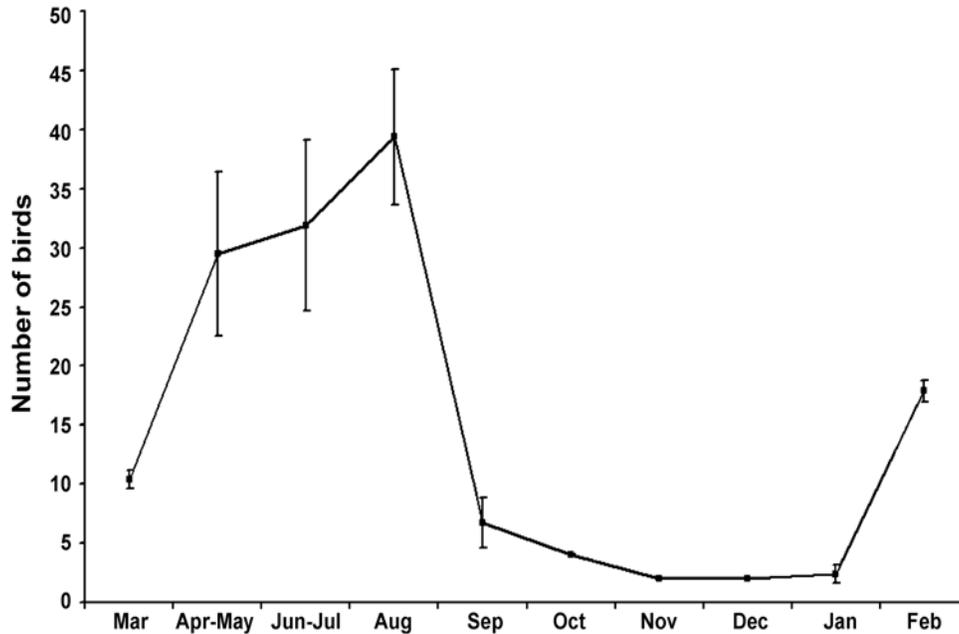


FIG. 2. Monthly variation in the mean ( $\pm$  SE) number of Military Macaws registered in the Sabino Canyon, Oaxaca, Mexico.

616 h). Surveys were made from 4 fixed observation points located on rock overlooks at the top of the canyon separated between 150 and 250 m, from which we had a 180° view of the canyon and roost area. We used four teams of two observers, for four lookout points. Teams communicated by radio in order to minimize double counting birds flying within the canyon, or birds flying away from the roost (Cougill & Marsden 2004).

Surveys were conducted in the morning from dawn until all of the birds had left the canyon, and in the afternoon from 17:00 h till dusk. During each survey period, we recorded the number of birds seen, activity (flying or perched), group size (1, 2, 3, 4, or 5+ birds), and time of detection. Data on group sizes were recorded throughout the year to provide

an indication of potential breeding pairs in the population, and recruitment of juveniles to the population (Forshaw 1977). Additional information on breeding activity of Military Macaws in the canyon was obtained from intensive observations conducted from the three lookout points.

*Nesting behavior.* Observations on breeding behavior of the macaws were conducted from 05:00 h (before sunrise) until 20:00 h (after sunset), to record activity of nesting macaws throughout the day. Total observation time devoted to breeding activities was 1155 h. Canyon walls were surveyed using a telescope for the presence of cavities, for cavities inspected by macaws, and for active nests throughout the season. All big holes (bigger than macaws) were inspected visually. A map

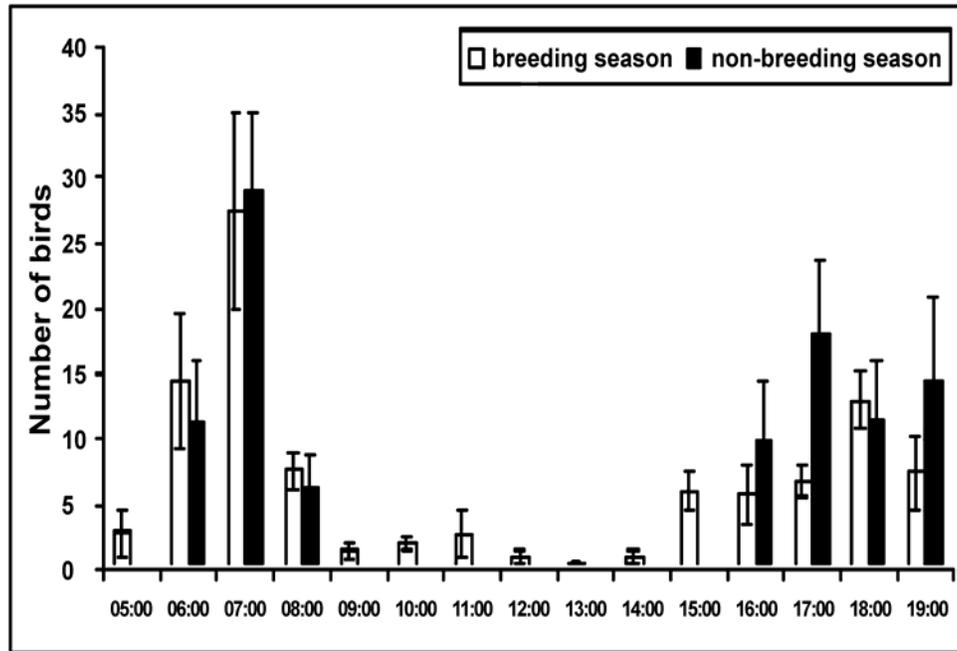


FIG. 3. Hourly variation in the mean ( $\pm$  SE) number of macaws recorded during the breeding and non-breeding season in the Sabino Canyon Oaxaca, México.

of each slope was drawn to be used during observations.

Data were recorded on courtship and mating when observed. We conducted cavity searches when a pair was observed making short flights to land near a potential hole in the canyon walls, and when birds made brief inspections of the hole (Boussekey *et al.* 1991). Incubation was assumed when one bird remained in the cavity throughout the day, while the other feed the incubating bird (Boussekey *et al.* 1991).

*Statistical analyses.* Monthly variation in bird numbers registered in the canyon were analysed using a Kruskal-Wallis ANOVA test. Hourly variations during days were analysed using one-way ANOVA with data Log10 transformed. Data were previously checked for normality using a Kolmogorov-Smirnov

test. For analysis of group sizes we used a Chi-squared contingency table. We report means with standard errors. Analyses were performed using JMP (SAS, 2000). Statistical significance was stated as  $P < 0.05$ .

## RESULTS

*Variation in macaw abundance and activity.* We recorded a maximum number of 67 macaws in the Sabino Canyon, Santa María Tecoma-vaca, during 1 year of monthly observations. Birds used the area as a roosting and nesting site from February until October (616 h of censuses, Fig. 2). There was a difference between months in the numbers of macaws recorded in the canyon (Kruskal-Wallis ANOVA  $H = 40.12$ ,  $df = 9$ ,  $P = 0.0001$ ). Greater numbers of macaws used the canyon between April and August (April–May  $29.5 \pm$

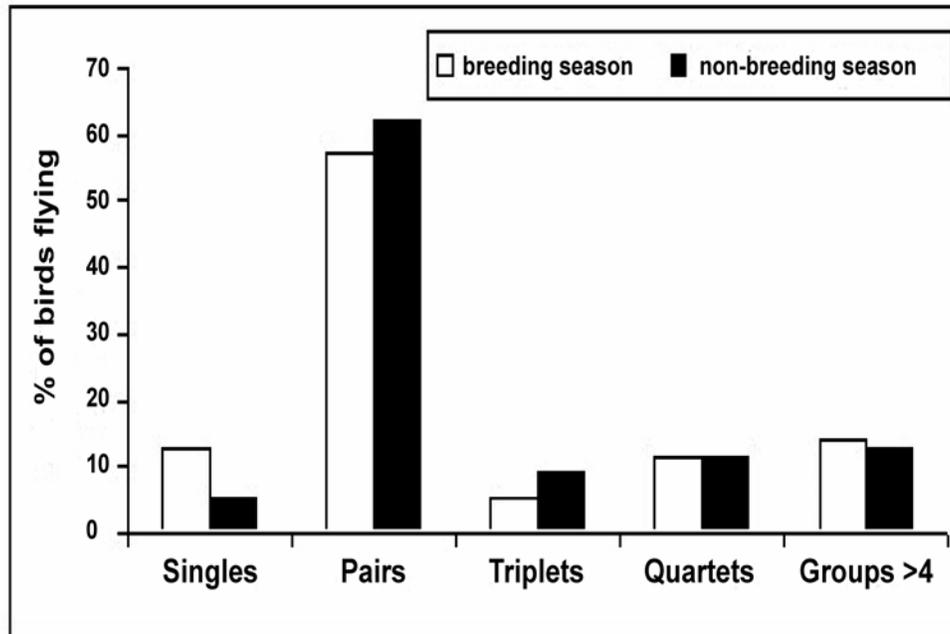


FIG. 4. Group size variation of the Military Macaws during the breeding and non-breeding seasons in the Sabino Canyon, Oaxaca, México.

6.9, June–July  $31.9 \pm 7.2$ , August  $39.4 \pm 5.7$ ), with fewer birds recorded from October to January (only one pair from November to January, Fig. 2).

The number of macaws flying in the canyon also varied with the hours of the day ( $F_{14, 135} = 2.5$ ,  $P = 0.005$ ). Two peaks could be identified when the highest numbers of macaws were in the canyon; one in the early morning (06:00–07:00 h), and another in the late-afternoon (18:00 h) (Fig. 3).

We observed pairs more frequently at the Sabino Canyon throughout the year ( $\chi^2 = 9.8$   $df = 4$ ,  $P = 0.04$ , Fig. 4). Solitary birds were infrequently observed, but the proportion of single birds was slightly higher at the beginning of the nesting period (March). The proportion of groups of 3 or 4 birds flying in the canyon also increased from September to October at the end of the nesting

period; they probably represented family groups.

*Nesting behavior.* Military Macaws in Sabino Canyon used cavities in vertical limestone walls of the canyon as nest sites. Courtship and mating behavior were observed in March, though copulation was also observed in May and July (11 events registered). Mated pairs also undertook a period of cavity searching, in which both birds investigated numerous holes in the canyon walls.

The southwest slope (measuring 720.8 m in width) presented 162 visible cavities, of which 30 were inspected by macaws (18.5%) and four were used for nesting (2.4%). In the northwest slope, we observed a total of 65 cavities; 10 were inspected by macaws (15.3%), and one was used for nesting (1.5%). During cavity inspections, pairs spent  $5.2 \pm$

1.3 min at each hole and, when the cavity was chosen, birds stayed in it between 1 to 3 h. Cavity searches occurred during May.

During the incubation period (from June to July), one bird, presumably the female, (Forshaw 1977) stayed in the nest and the male returned  $2.3 \pm 0.5$  times a day to feed her. Females stayed out of the nest with the males during feeding periods for  $37.5 \pm 1.9$  min ( $n = 2$  nests).

At the end of July, both parents left the nest and occasionally the young could be seen with their head out of the opening. Adults returned to the nest  $2.6 \pm 0.5$  times a day. Both parents entered the nest and stayed  $15.4 \pm 4.0$  min during each visit ( $n = 1$  nest). Nestlings were detected approaching the nest entrance in September, and two young were observed fledging from one nest in October ( $n = 1$  nest).

## DISCUSSION

The nesting colony reported in Sabino Canyon inhabits a much drier habitat than that normally reported for the species (Forshaw 1977, BirdLife International 2003), comprised of tropical deciduous forest dominated by columnar cacti (Valiente-Banuet *et al.* 2000). In this area, trees are lower than in semi-deciduous forests, and lose their leaves during the long dry season. Diameter of sampled trees in the zone (Contreras-González 2007) was less than suitable for nesting macaws (need DBH = 50 cm Forshaw 1977, del Hoyo *et al.* 1997, Brightsmith 2005a, 2005b, 2005c).

A high abundance of columnar cacti may compensate for the apparent lack of other food sources during the dry season because they produce edible flowers and fruits that are eaten by macaws from April to June (Contreras-González 2007). The dry forest habitat of Sabino Canyon may represent a sub-optimal habitat for Military Macaws with a low seasonal abundance of food, but may also

represent a fairly safe site, in relation to the pet trade commerce, for nesting and roosting.

The reproductive success of Military Macaws in Sabino Canyon was low, with very few observed fledglings. This pattern agrees with other findings for the *Ara* genus and for Psittacidae that are long-lived, reach sexual maturity late, and have low reproductive outputs (Forshaw 1977, Boussekey *et al.* 1991, Carreón 1997).

Compared with other colonies of Military Macaws studied in Mexico, the percentage of birds observed nesting in the Sabino Canyon (15%) is comparable to estimates of 9% and 23% of birds nesting at 2 sites in Queretaro (Gaucín 2000), but is much lower than the estimate of 67% of birds nesting in Cajon de Peñas, Jalisco (Carreón 1997, Loza 1997). In the two Queretaro sites (Gaucín 2000), as in Sabino Canyon, Military Macaws nested in holes in the limestone walls whereas, in Cajon de Peñas on the Pacific slope, macaws nested in tree cavities (Forshaw 1977, Carreón 1997, Loza 1997).

The vegetation and dry climate of Santa Maria Tecomavaca (in Oaxaca) and Queretaro sites are similar, while Cajon de Peñas is more humid with dominant tropical semi-deciduous forest and larger trees than the ones sampled in our study site (Bullock & Solís-Magallanes 1990).

The survey data demonstrated seasonal variation in the number of macaws recorded in Sabino Canyon, with the highest numbers between April and September, and a sharp decline in the number of macaws using the canyon between October and February. The colony moves out by late October to a nearby area located near Coyula where tropical deciduous forest and oak forest are present. These movements may be related to seasonal changes in food resources and abundances (Contreras-González 2007).

Greater numbers of macaws were found in the canyon during the first 2–3 h of the

morning, and the last 3–4 h of the afternoon. The morning departure period was shorter and may be more effective for counting birds in the canyon; similar results were reported by Coughill & Marsden (2004) for roosting Amazon parrots in Brazil.

In the Sabino Canyon, breeding occurred during March and September. However, on the Pacific coast of Mexico, the Military Macaw is reported breeding from October to February (Carreón 1997, Loza 1997), as for other species of macaws in South America (Forshaw 1977, Brightsmith 2005a).

This variation in the breeding season of Military Macaws in Central Mexico could be related to differences in the seasonal availability of fruits. In the dry forests of the Mexican Pacific slope, the peak fruiting activity of trees occurs between February and March (Bullock & Solis-Magallanes 1990, Renton 2001, Renton & Salinas-Melgoza 2004) but, in Tecomavaca in Central Mexico, the peak fruiting of columnar cacti takes place during June–July (Valiente-Banuet *et al.* 1996). In Durango, Mexico, the Military Macaw is reported to initiate nesting in March; however, Fleming & Baker (1963) reported an active nest containing two eggs in July. The seasonal differences in nesting may be due to differences in diet and food availability (Brightsmith 2005a).

The colony of Military Macaws in the Sabino Canyon of Santa María Tecomavaca inhabits a well preserved area, situated in a remote section of the Tehuacán-Cuicatlán Biosphere Reserve. A long term monitoring program to survey seasonal variation in abundance and reproductive success is needed along with a protection program for this canyon. The low reproductive success observed during this study can be attributed to many factors, including climate, vegetation production, natural nest predation and intrinsic population factors. A detailed multi-year

analysis will help to elucidate this pattern more clearly.

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