The Wilson Journal of Ornithology 130(4):859–868, 2018

Population assessment of Military Macaw (*Ara militaris*) inhabiting the southern coastal forests of Bahía de Banderas, Jalisco, Mexico

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ABSTRACT—Despite the broad environmental tolerance of the Military Macaw (*Ara militaris*) reflected in its wide ecological distribution, most surveyed populations in the few studied breeding areas in Mexico present <100 individuals. Although records of the species include several regions across the country, most groups recorded include <50 macaws. Prior to this report, the largest known breeding Mexican population documented was the Tehuacán-Cuicatlán nesting colony with 100 macaws. Over the last 8 years, we surveyed the macaw population nesting in tropical coastal forests located in the southern portions of Bahia de Banderas, the bay where Puerto Vallarta in Jalisco is located. We systematically assessed the macaw population by counting the flocks occurring in 3 forested areas located 20–37 km apart and assumed to harbor different and independent macaw groups. The macaw abundance was surveyed during 35 consecutive months from February 2012 through December 2014. Based on location of the surveys, the timing of the observations, and the flight direction of the 3 distinct macaw groups, we inferred that each uses different foraging, roosting, and nesting areas. Higher abundance for each population was observed during February–May each year, contrasting with a low level of activity observed during the summer months of July–August. We assumed that the macaws exhibit nomadic behavior outside the region during summer. The 3 populations may constitute a metapopulation that congregates after the fledglings acquire flying skills during the initial months of the nonbreeding season on the 3 different areas. During March 2013, the highest concentration was registered in the Yelapa region, where 215 macaws were observed in a colonial roost, constituting the largest aggregation documented for the species. If data from the 3 populations surveyed are combined, the estimated number of macaws is 363 birds for 2014. Based on our data, we believe the region harbors a vital population for the long-term survival of the Military Macaw in central western Pacific and Mexico. *Received 7 July 2017. Accepted 4 July 2018.*

Key words: *Ara militaris*, flying routes, metapopulation, Puerto Vallarta, seasonal abundance patterns.

Evaluación de la población de Guacamaya Verde (*Ara militaris*) en los bosques costeros del sur de Bahía de Banderas, Jalisco, México

RESUMEN (Spanish)—A pesar de la amplia tolerancia ambiental de la guacamaya verde (*Ara militaris*), reflejada en su extensa distribución ecológica, la mayoría de las poblaciones de las pocas áreas de anidación estudiadas en México están integradas por menos de 100 individuos. Aunque los registros de la especie incluyen varias regiones del país, la mayoría de los grupos registrados presentan <50 guacamayas. Previo a este reporte, la población reproductiva documentada como más numerosa en México era la de la colonia de anidación de Tehuacán-Cuicatlán con alrededor de 100 guacamayas. Durante los últimos ocho años, evaluamos una población de guacamaya que anida en bosques tropicales costeros de las porciones sur de Bahía de Banderas, cerca de Puerto Vallarta, en Jalisco. Evaluamos sistemáticamente a la población, contabilizando las parvadas que ocurren en tres áreas forestales separadas entre 20–37 km, que se presume contienen grupos de guacamayas distintos. La abundancia fue muestreada durante 35 meses consecutivos, de Febrero de 2012 hasta Diciembre de 2014. Considerando la ubicación de los sitios de muestreo, la temporalidad de las observaciones, y las direcciones de vuelo de los tres grupos de guacamayas, inferimos que cada uno utiliza distintas áreas para descansar, anidar y alimentarse. La mayor abundancia de cada población se observó durante el periodo Febrero-Mayo en cada año, contrastando con menor nivel de actividad observada durante el verano en los meses de Julio-Agosto. Asumimos que las guacamayas exhiben conducta nomádica durante el verano fuera de la región. Las tres poblaciones podrían constituir una metapoblación que se congrega después de que los volantones adquieren las habilidades de vuelo durante los meses iniciales de la época no reproductiva en tres áreas distintas. Durante Marzo de 2013 se observa la mayor concentración en la región de Yelapa, donde se observó 215 guacamayas en un dormidero colonial. Este número constituye la mayor agregación documentada para la especie. Si se combinan los datos de las tres poblaciones muestreadas, el número estimado de guacamayas es de 363 aves en el año 2014. Basados en los datos, creemos que la región alberga una población vital para la sobrevivencia a largo plazo de la especie en el centro oeste del Pacifico y para México.

Palabras clave: *Ara militaris*, metapoblación, patrones estacionales de abundancia, Puerto Vallarta, rutas de vuelo.

Among the Mexican psittacine species, the Military Macaw (*Ara militaris*) stands out as the species of the genus *Ara* with the northernmost distribution and is the only *Ara* species that nests in cliff crevices as well as in tree cavities (Reyes-Macedo 2007, Bonilla-Ruz et al. 2014b). It occupies tropical environments (e.g., tropical dry forest in Oaxaca) as well as Nearctic biomes such as the conifer forests of Sonora and Durango (Forshaw 1989, Sierra-Franco 2006). The species' historical distribution in Mexico included the

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Pacific slope from Sonora in the north to the Chiapas coast in the south, and along northern Gulf of Mexico slope from Nuevo Leon and Tamaulipas to Puebla and Oaxaca in the south (Forshaw 1989, Collar and Juniper 1992, Peterson and Chalif 1998, Howell and Webb 2001). The Military Macaw's wide historical distribution illustrates its remarkable environmental tolerance and exhibits its behavioral differences as well as tolerance to different local toxicity levels on their local diets as macaws feed from a broad variety of nuts and fruits (Loza 1997, Sierra-Franco 2006, Martínez and Bonilla 2008, Contreras-González et al. 2009, De la Parra-Martínez et al. 2015). However, most of the intensively surveyed known populations are notably small (Avilés-Ramos 2016). The species' contemporary distribution is evidence of its decline; the species has been extirpated from all the coastal areas from Chiapas to Colima on the South Pacific coast of Mexico (Marín-Togo et al. 2012, Monterrubio-Rico et al. 2016).

Although suitable habitat for the species is present almost continuously along the Sierra Madre Occidental and Sierra Madre del Sur from Sonora to the Lower Balsas in Michoacán (Marín-Togo et al. 2012) and along the Sierra Madre Oriental from Tamaulipas to Querétaro (SEMARNAT-CONANP 2012), an accurate estimate of regional population sizes is urgently needed (Monterrubio-Rico et al. 2016). Mexico has the highest number of published studies concerning the size of local Military Macaw populations (Carreón 1997, Gaucín 1999, Bonilla-Ruz et al. 2007a, Rivera-Ortíz et al. 2008, Avilés-Ramos 2016); the largest population documented corresponds to a nesting area with ~100 macaws in the Biosphere Reserve Tehuacán-Cuicatlán, Oaxaca (Bonilla-Ruz et al. 2007a, Reyes-Macedo 2007). Other population estimates range from 30 to 90 birds from areas such as Sierra Gorda in Querétaro, Salto de Agua Llovida in Durango, or the Cajón de Peñas area in Jalisco (Carreón 1997, Gaucín 1999, Íñigo-Elías 1999, Sierra-Franco 2006). In South America, reports documenting the species' population sizes are scarce; the only published report documenting the size of a local population is for Antioquia, Colombia, where the reported estimated number is 156 individuals (Flores and Sierra 2004, Navarro et al. 2008, Hosner et al. 2009, Stotz and Mena-Valenzuela 2009).

Estimating the population abundance of the Military Macaw is not an easy endeavor, especially during the nonbreeding season when the species is known to exhibit a nomadic behavior, assumed a response to the peaks of local abundance of fruits and seeds across its range (Myers and Vaughan 2004). During the breeding season, however, pairs' foraging trips are restricted to nearby areas because they must return to feed their chicks throughout the day (Bonilla-Ruz et al. 2007a). During the nesting and fledgling stages of their nesting seasons, estimates of the size of local populations are easier to obtain because the macaws exhibit a high degree of area fidelity that lasts between 5 to 6 months. The nesting season offers the opportunity to perform systematic counts to document changes in abundance with greater certainty. This information is particularly important to visualize the potential changes associated with the annual recruitment stage in areas where nesting activities are known. Fledglings can also be identified during their initial flights by their more insecure, less maneuverable flight, and by vocalizations. Changes in the size of the flocks followed during nest monitoring may help estimate the reproductive output of the overall population (Gómez-Garduño 2004, Bonilla-Ruz et al. 2007a, Martínez and Bonilla 2008, Juárez et al. 2012). Because of nomadic behavior during the nonbreeding season, the local population size estimates in the species show considerable variation between nesting vs. postreproductive seasons (Carreón 1997, Gaucín 1999, Bonilla-Ruz et al. 2007a, Rivera-Ortiz et al. 2008).

The Bahía de Banderas region, shared by Nayarit and Jalisco states, is considered a priority area for conservation (Arriaga et al. 2000). The region still maintains large and continuous pristine tropical forests where tourists and bird watchers have observed intensive flock activity during recent years (CONABIO-NABCI 2016); however, a systematic survey effort for the region was lacking and urgently needed. Preliminary observations of the flight routes allowed us to assume the existence of a metapopulation characterized by at least 3 different local populations in the southern part of the bay. The populations nest in different areas but probably congregate in large groups at feeding areas, with each population or group using different flyways and colonial roosting sites (Bonilla-Ruz et al. 2014a).

One way to estimate the Military Macaw population size in the region was to determine the degree of independence of the macaw groups inhabiting the different areas of the bay. Therefore, we simultaneously surveyed the 3 populations by counts at strategically located sites and by observing flight directions, the forest fragment destination, and areas where each group (population) perched for feeding or roosting.

Our first aim was to ensure the degree of consistency in the geographical separation, ensuring that the macaws observed in one area did not include macaws from the other areas. Considering the current scenario of transformation of the remaining mature forest fragments, increased recently by the expansion of touristic real estate developments, evidence of the importance of the forests for this endangered species is urgently needed. The population found in these remaining forest fragments may also represent the most numerous macaw population. Thus, the aims of this study were to (1) determine a minimum population size of the Military Macaw for the southern portion of the Bahía de Banderas area; (2) determine if the macaws observed on the different forested areas constitute a single population or geographically separated populations that eventually make up a regional metapopulation, and (3) examine how the abundance of the species varies through the year in each of 3 surveyed areas.

Study site

The study area was located on the central and southern portions of Bahía de Banderas, in the municipalities of Puerto Vallarta (Central) and Cabo Corrientes (South) in Jalisco state, Mexico. The surveys were conducted from elevated sites with 360° visibility. A clear view above the tree canopy was achieved for the 3 areas. The first survey site was east of Puerto Vallarta city on Ejido El Jorullo (20°34′44.03″N, 105°12′5.95″W), the second site southeast of Yelapa town (20°28′14.82″N, 105°25′43.87″W), and the third southwest of the town of El Tuito (20°17′16.78″N; 105°22′35.46″W; Fig. 1). The distance between the locations ranged from 20.4 km (El Tuito–Yelapa) to 37 km (El Jorullo–El Tuito).

In the localities of El Jorullo and Yelapa, the primary vegetation is subdeciduous tropical forest while the predominant vegetation in the El Tuito locality is oak forest, and to a lesser extent subdeciduous tropical forest (INEGI 2015).

Methods

Preliminary surveys and exploratory field work to observe movement patterns of flocks as well as nesting and foraging areas were conducted from elevated hilltops around the bay between May 2008 and June 2010. During this time we conducted 15 survey periods (each period consisted of 3 or 4 count sessions in a single month). Maintaining a geographical separation of >20 km, 3 populations were identified as particularly important, and for each an elevated site was selected as a vantage point from which to survey the activity (Bibby et al. 1992, Ralph et al. 1996).

The strategic location of the survey sites for the counts allowed us to identify the main macaw flight routes used when moving from their roosting areas on the forested hills to their feeding sites. The procedure was similar to the methodology employed for raptors and included the notation of flock size and number of family groups or pairs; macaws usually fly in formation of family groups or related pairs (Gilardi and Munn 1998, Renton 2002, Cougill and Marsden 2004, Karubian et al. 2005, Bonilla-Ruz et al. 2007a, Rivera-Ortiz et al. 2008).

The counts were performed before sunrise (~0645 h), and to avoid double counting of individuals, each count lasted until the first macaw flew back from the opposite direction or from the identified feeding areas (~0930 h; Cougill and Marsden 2004). Additional data recorded included the start time of each survey session, the time at which each flock or macaw pair was detected, the number of individuals, the direction from which each macaw flew, and the direction the macaws were heading as broad categories (N, NE, E, SE, S, SW, and W). To avoid or reduce double counting, all macaws coming from directions not corresponding to the known roosting areas were recorded but were not included in the estimates of the survey session.

The performed counts occurred once a month and consisted of 2 or 3 sessions on consecutive days in each site. The counts for the 3 populations were performed simultaneously when experienced personnel were available. The surveys at El Jorullo

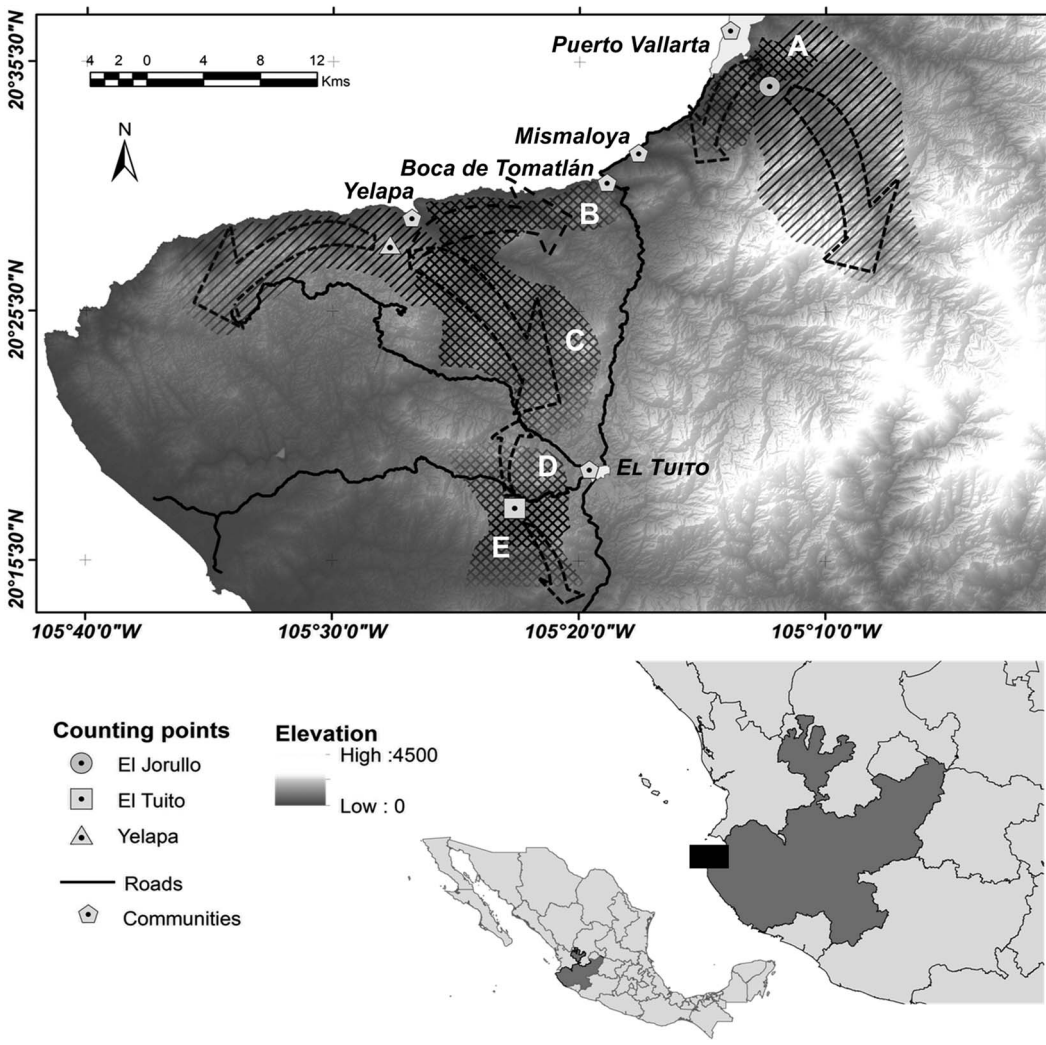

Figure 1. Study area with survey locations and major flight routes (arrows), defining general areas used by Military Macaw populations to the south of Bahía de Banderas, Jalisco (hatched). Cross-hatched areas correspond to areas used by the macaws that represent areas of possible connection and exchange between populations found during the study. A to B represents the connection between El Jorullo and Yelapa; C to D the connection between Yelapa and El Tuito; and E the possible connection to Cajon de Peñas (see text). Geographical source: INEGI 2015.

initiated on February 2012 and lasted until December 2014 for 35 monthly counts. In Yelapa, counts lasted from November 2012 through June 2014, for 20 monthly counts. In El Tuito the survey period lasted from November 2012 to September 2014, for 23 months of surveys (Fig. 2).

Although the use of circular statistics (Rayleigh test) was our first consideration to evaluate bearings of the flying routes, such rigorous analysis was not possible because it required precise compass bearings in degrees. The macaws' flyway bearings could only be registered on a few occasions, so the frequency and consistency of the flying direction of the flocks over time were analyzed by season separately in each population using chi square test (χ^2), contrasting the null hypothesis of macaw flights occurring with a random destination. The level of significance used for the statistical tests was $\alpha = 0.05$. The

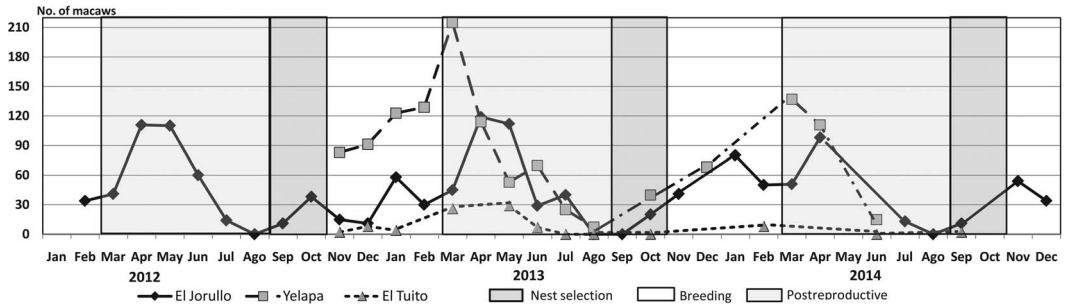

Figure 2. Population counts on the counting points conducted during 2012–2014 to the south of Bahía de Banderas, Jalisco. The shaded areas represent different stages of the reproduction season (according to Bonilla et al. 2014b and Avilés-Ramos 2016).

seasonality was taken from January every 3 months, from winter to autumn.

Results

Population size

The largest Military Macaw abundance was recorded in the Yelapa population, and throughout the surveyed months it maintained the most abundant numbers, although significant seasonal variation was observed during summers when activity in the area decreased (Jul–Sep; Fig. 2). The highest number of macaws was recorded during the March 2013 survey, when 215 macaws flew along a route that departs from a mountainside where macaws roosted colonially. The second largest population corresponded to El Jorullo, with a maximum count of 119 individuals (Apr 2012; Fig. 2). Among the 3 surveyed sites, the lowest macaw number was observed at El Tuito, with a maximum estimated population of 29 individuals. In general, the population size rankings among the 3 localities was maintained throughout the entire study, and the changes in abundance in each population exhibited similar patterns in relation with the nesting phases registered in a focal group of nesting pairs from a parallel study (Aviles-Ramos 2016).

Another noteworthy pattern was that the largest numbers corresponded to the end of the nesting and the beginning of postreproductive seasons for all 3 areas (Fig. 2), coinciding with the fledging period in the region, which is during the last days of March and April (Bonilla-Ruz et al. 2014b, Avilés-Ramos 2016). During July to early October, macaw activity was not observed at El Jorullo or El Tuito (Fig. 2) but was observed in Yelapa, the unique area where the species maintained activity throughout the year, although with a small minimum of 7 macaws. During the study, the periods with the highest abundance were slightly asynchronous among the areas, with Yelapa having its greatest abundance during March and El Jorullo and El Tutito during April.

Flying routes

We analyzed 3,218 individual Military Macaw flights by season in terms flyways and destinations. The average number of individual flights per survey session was 108.4 (SD 66.6) in Yelapa, followed by 33.9 (33.6) in El Jorullo, and 12.8 (10) in El Tuito. According to the χ^2 tests, distinctive seasonal changes were evident in the registered flight directions (P always <0.001). In the Yelapa locality, 3 predominant areas corresponded to the macaws' flyways: the coastal forested hills between Yelapa and Boca de Tomatlán town to the East (40.5%; $n = 745$); the higher Tuito River basin (S–SE, 7.3%; $n = 316$); and to the coastal forests toward Cabo Corrientes (W–NW, 24.3%; $n = 447$), totaling 1842 individual flights (Fig. 1).

In El Jorullo, the most consistent flyways were S, SW, and SE bearings, with 93.8% of the observations based on 1,146 total individual flights observed. The SE and S flyways ($n = 962$; 78.7%) correspond to the higher Cuale River basin as the likely destination, whereas the SW course ($n = 184$; 15.1%) corresponds to the forested hillsides of the coastal area between Puerto Vallarta and Boca de Tomatlán town (Fig. 1). The direction of the movements from the population at El Tuito

were less clear geographically, probably because the number of records was low. However, all the movements were associated with the use of the forested hills located north and south of the El Tuito counting point, based on 154 observations, suggesting a N–S corridor (Fig. 1).

Except for data from El Tuito based on a low number of observations ($n = 154$), we found evidence of some seasonal changes in the relative importance of flight directions. Thus, in El Jorullo, the SW flight direction, which defines the coastal zone between Puerto Vallarta and nearby east of Boca de Tomatlan, is most important in winter and spring; that is, during the second half of the breeding season and the first postreproductive months (winter $n = 347$, spring $n = 548$; $P = 0.000$; Fig. 1A). Coincidentally, in Yelapa, flights toward SE and E that corresponded, respectively, to the regions between communities of Yelapa and Boca de Tomatlan and the El Tuito river basin are important during the winter (Fig. 1, points B and C).

Discussion

Population size

Our surveys indicated that the coastal forests of the entire southern portion of the Bahía de Banderas are used by the largest documented metapopulation of Military Macaw. The greatest macaw activity was registered from February to May on the forested hillsides located between Puerto Vallarta and Cabo Corrientes. The evidence obtained during the surveys (distance among the areas, different flyways, survey procedures, and areas of activity) indicated that the populations may constitute independent macaw populations during the nesting season, but some contact between populations may occur during the nonbreeding season because they may forage in some of the same areas. The populations from the 3 areas varied slightly in their abundance patterns; the maximum abundance occurred in March in Yelapa and in May in the El Jorullo and El Tuito populations (Fig. 2).

Seasonal changes in local abundance of the Military Macaw occur in all known nesting populations in Mexico (Carreón 1997, Gaucín 1999, Gómez-Garduño 2004, Bonilla-Ruz et al. 2007a, Rivera-Ortiz et al. 2008, Rubio-Rocha 2015). The seasonal movements in each of the known nesting regions are assumed to respond to changes in local food availability, particularly in forests of the dry tropics that fluctuate in seed and fruit production, as observed in other Psittacidae in Western Mexico (Monterrubio-Rico et al. 2016). This hypothesis suggests that the nutritional needs of the fledglings differ between the nestling phase and recruitment phase. In addition, the diversity of the trees in the forest assemblages were assumed to influence the use or selection of specific forest stands according to flock observations (Bonilla-Ruz et al. 2007b, Martínez and Bonilla 2008, Contreras-González et al. 2009). The hypothesis was also supported by results from a detailed floristic study evidencing that macaw nesting and feeding areas differ in species diversity and composition compared with random unused forest sites of the region (Flores-López 2018).

The combined abundance of the 3 populations constitute the largest known Military Macaw metapopulation in Mexico (close to 400), which nest in separate but neighboring areas of the region (Bonilla-Ruz et al. 2014b, Avilés-Ramos 2016). The Yelapa population, with a maximum of 215 individuals, is larger than the population recorded in Antioquia, Colombia (156 individuals), by Flores and Sierra (2004). Furthermore, the population observed on El Jorullo with 119 macaws is slightly larger than the largest Mexican population published in the scientific literature, the Tehuacán-Cuicatlán population (Bonilla-Ruz et al. 2007a, Reyes-Macedo 2007). Unfortunately, the third population studied in the region (El Tuito population), with <50 individuals, is suffering constant nest poaching, including the logging of nesting trees for the extraction of the macaw chicks, as informed by local villagers and the evidence of the loss of logged trees used by nesting pairs. Ensuring conservation of this macaw population, which is under imminent threat, requires immediate official protection and management actions as well as environmental education efforts on nearby communities.

We hypothesize that the abundance data obtained in this study may indicate that the forests on the southern section of Bahia de Banderas are more suitable for the species than most of the known nesting areas. A combination of factors support this hypothesis, including a high density of nesting pairs, gregarious nesting behavior, and constant high productivity and success rates

(≥70%) documented in a parallel study in the area (Bonilla-Ruz et al. 2014b, Avilés-Ramos 2016). Although the most direct evidence comes from the survey results, the literature indicates that habitat suitability in colonial species such as wading birds and psittacines correlates directly with the local abundance of the populations and their reproductive success (Drechsler et al. 1998, Pavey et al. 2014, Beerens et al. 2015, Annorbah et al. 2016).

The Bahía de Banderas overall population size may potentially be larger than the 400 individuals observed on its southern portion. About 70 macaws were observed using forests northeast of the Puerto Vallarta mountains in Jalisco and on the Nayarit side (northern portion of the bay) during a winter bird count study in Puerto Vallarta, indicating a separate population (Carrillo et al. 2013). Because of logistical limitations, systematic survey effort was concentrated only on the larger populations of the southern side of the bay, and limited survey effort was performed for the northern section of Nayarit. Given the consistency of southbound flight paths observed at the northernmost survey point (El Jorullo), the Nayarit (northern side of the bay) birds almost certainly constitute a separate population.

Conservation implications

In recent years, field work with the Military Macaw has provided data on their feeding, reproduction, and roosting activity (Bonilla-Ruz et al. 2014b, Avilés-Ramos 2016). They consistently use the observed flyways each year, allowing us to identify the key areas for the species conservation in the study area. One of these, the Cuale River basin, has been proposed previously as a protected area because of its high biodiversity, the presence of endemic and endangered species, and the environmental services it provides to Puerto Vallarta city (Téllez and Delgado 2011). Another important area is the coastal mountain chain between Puerto Vallarta and Boca de Tomatlán, where coastal forests provide a foraging area from September to March (Fig. 1, point A). The third area is the coastal zone between Yelapa and Boca de Tomatlán (Fig. 1, point B). Because Yelapa and El Jorullo populations constitute the largest Military Macaw population currently known, the coastal area between Yelapa and Boca de Tomatlán and the Cuale River basin should concentrate the largest number of active nesting pairs, which is consistent with nest density estimates (Bonilla-Ruz et al. 2014b, Avilés-Ramos 2016). Searches for nesting activity, however, have covered only part of the former area (Bonilla-Ruz et al. 2014b). The forests around El Tuito seem to be particularly important in maintaining a potential connectivity with a macaw population nesting in the area known as Cajón de Peñas, only 30 km away (Carreón 1997, Loza 1997, De la Parra-Martínez et al. 2015). The forest extent and precise location of the nesting sites for this area are still unknown, however, and future field survey effort is required to better define this area, which deserves priority conservation (Fig. 1, point E).

If the surveyed Bahía de Banderas populations have a similar proportion of nesting pairs (10–20%), as documented by other authors for several macaw species (Munn 1992) or for the Military Macaw (Reyes-Macedo 2007), we assume that the 17 nesting pairs surveyed by Avilés-Ramos (2016) correspond to an adequate proportion of breeding pairs for an overall population ~340 macaws (Avilés-Ramos 2016). The total number of nesting pairs each year for the entire area is still unknown, and only 10% of the suitable area has been explored for nesting trees and pairs; therefore, the minimum number of Military Macaws in the surveyed areas (360 macaws) may be conservative. A higher number of macaws may be expected if we consider that the number of nesting pairs was found during intensive surveys of a low percentage of the available forested area. In addition, the forested mountains of the northern portion of the bay also have several localities with flocks of Military Macaw that have not been systematically surveyed (Carrillo et al. 2013). Future research should also determine the number of nesting pairs nesting in each of the 3 populations surveyed to examine the proportion of breeders for each group.

Because of its location, the metapopulation in the region may constitute the key stronghold for the species in the Central Pacific, and therefore survey effort should continue around the entire bay. All the nesting areas should be identified to design adequate management, restoration, and conservation actions. The carrying capacity of the forest for the macaw population should be determined. A viable local population of 500 macaws with probably 50 nesting pairs per year

could be feasible considering a proportion of 10–20% nesting pairs each year. Similar estimates (360–400 macaws) were obtained for a viable local macaw population of Red and Green Macaws (*Ara chloroptera*) in a preserved forest area with similar dimension 163.4 km^2 (Munn 1992).

Ideally, the southern side of Bahia de Banderas should be considered a source population of macaws because it is probably the only area where the species productivity might be enhanced with adequate management (nest boxes). Continued monitoring of abundance and movement patterns is crucial, and satellite telemetry should be implemented to confirm the species main flyways, foraging areas, and regions of destination of the macaw populations when they are not nesting. The populations' viability must be modeled considering actual knowledge (abundance, number of nesting pairs, productivity, and nesting success rates) and different threat scenarios of landscape modifications by using vortex models. Genetic structure and exchange among the different populations should be determined.

Because all these macaws inhabit unprotected areas, collaborative agreements among stakeholders and environmental authorities in the region are urgent. In the Puerto Vallarta area, the tourism industry may play an important role, including the responsibility to promote environmentally friendly real estate development instead of the traditional tourist developments that trigger forest loss and degradation. This is the only resort area where 5-star hotels are located within walking distances to observe both macaws in their habitats and humpback whales (*Megaptera novaeangliae*) in the bay, and such a combination creates a unique opportunity for a more environmentally friendly vision of the tourism industry for Mexico.

Acknowledgments

We appreciate feedback on the statistical analysis of Antonio Santos Moreno; logistical support from Bonnie Jaregui and Cherryl Harleston to carry out the monitoring in El Tuito and Yelapa. Thank you to Anna Luijten, Alex Martínez, and Roberto Ornelas for obtaining field data in some monthly monitoring sessions. Part of the field work was carried out with the financial support of the National Commission of Natural Protected Areas (grant code CONANP-PROCER project/DGOR/04/2014); and the decided support of Susan Payne and Jennifer Weber from the Canadian Parrot Conference in Kitchener, ON, Canada.

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