ORNITOLOGIA NEOTROPICAL 25, 345–353, 2014

OWLS IN OAK AND PINE FORESTS IN LA MALINCHE NATIONAL PARK, MEXICO

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Resumen. – Búhos de los bosques de encino y pino del Parque Nacional La Malinche, México. – Se conoce poco sobre los búhos Neotropicales. En particular, en muchas zonas su presencia no ha sido confirmada y varios parámetros sobre estas poblaciones son desconocidos. Por lo tanto, nuestro estudio tuvo como objectivo evaluar la diversidad, asociación con hábitats y densidad de búhos del Parque Nacional La Malinche, que es la única área protegida del estado de Tlaxcala, México. Como resultado reportamos las siguientes siete especies: Lechuza de campanario (*Tyto alba*), Tecolote occidental (*Megascops kennicottii*), Tecolote rítmico (*M. trichopsis*), Búho cornudo (*Bubo virginianus*), Tecolote serrano (*Glaucidium gnoma*), Tecolote llanero (*Athene cunicularia*) y Tecolote afilador (*Aegolius acadicus*). Detectamos estas especies por conteo de puntos en tres tipos de vegetación (bosques de pino, encino y pino-encino) que cubren el area de estudio. La especie con mayor abundancia fue *M. kennicottii* (0.25 vocalizaciones/km^2), seguida por *B. virginianus* (0.23 vocalizaciones/km^2). Algunas especies presentaron una clara tendencia a usar diferentes tipos de vegetación. Por ejemplo, *M. kennicottii* fue registrada más frecuentemente en el bosque de encino, mientras su congénere *M. trichopsis*, sólo fue encontrado en bosque de pino. Nuestros resultados proveen el primer listado de los búhos que habitan esta área natural protegida y sugieren que los listados anteriores deben ser actualizados.

Abstract. – Little is known about Neotropical owls. In particular, in many areas their presence is unconfirmed and several parameters about these populations are unknown. Hence, our study aimed to assess the diversity, habitat association, and densities of owls inhabiting La Malinche National Park, the only natural protected area in the state of Tlaxcala, Mexico. As result we report seven owl species: Barn Owl (*Tyto alba*), Western Screech-Owl (M*egascops kennicottii*), Whiskered Screech-Owl (*M. trichopsis*), Great Horned Owl (*Bubo virginianus*), Northern Pygmy-Owl (*Glaucidium gnoma*), Burrowing Owl (*Athene cunicularia*), and Northern Saw-whet Owl (*Aegolius acadicus*). We detected these species by using point counts in three vegetation types (pine, oak, and mixed pine-oak forest) that occur in this natural protected area. The species with the highest number of vocalizations/km^2 was the Western Screech-Owl (0.25 vocalizations/km^2) followed by the Great Horned Owl (0.23). Some species showed a clear preference for a specific vegetation type; for example, the Western Screech-Owl was recorded with more frequency in oak forest, while its congener the Whiskered Screech-Owl was only recorded in pine forest. Our results provide the first list of the owl species inhabiting this natural protected area and suggest the need for updating existing species lists. *Accepted 21 October 2014.*

Key words: *Aegolius acadicus*, *Athene cunicularia*, *Bubo virginianus*, *Glaucidium gnoma*, *Megascops kennicottii*, *Megascops trichopsis*, *Tyto alba*, densities, habitat association, La Malinche National Park, Mexico, play-back, Strigidae, Tlaxcala.

INTRODUCTION

The success of biological conservation strategies depends on previous biodiversity knowledge on the areas where they are implemented. Unfortunately, for many protected areas in the Neotropics there are insufficient data about the presence and distribution of the species that inhabit them. This is the case for owls, whose presence has been suggested in many protected areas but locally has remained unconfirmed.

Owls are at the tops of food chains (Bruce 1999, Marks *et al.* 1999). Therefore these birds have special importance in ecosystem maintenance (Thiollay 1984, 1996; Jullien & Thiollay 1996). However, little is known about their population and conservation status, particularly for those species inhabiting the Neotropical Region (Takats *et al.* 2001, Enríquez *et al.* 2006, Owl Research Institute 2013), even when advances have been made at some local geographical scale (e.g., Vázquez-Pérez *et al.* 2011). Moreover, due to their cryptic behavior and difficulty of observing them, owls are one of the most difficult groups of birds to study (Proudfoot & Beasom 1996).

In Mexico, studies on owls are scarce (Enríquez *et al.* 1993, 2006, 2012; Alba-Zuñiga *et al.* 2009, Vázquez-Pérez *et al.* 2011, Rivera-Rivera *et al.* 2012, Valencia-Herverth *et al.* 2012). For example, no studies of this group in La Malinche National Park (LMNP), Tlaxcala, have been scientifically published. To date, there is no consensus about how many owl species inhabit LMNP. The number of species has been reported as low as four (Windfield 2001, Fernández *et al.* 2007, eBird 2013) and as high as 13 (CONABIO 2013). Furthermore, recent reports contradict each other concerning the identity of the species recorded (Windfield 2001, eBird 2013).

We report the results of an owl survey carried out in LMNP, an isolated fragment of temperate forest in central Mexico and the only natural protected area in the state of Tlaxcala. Our goals were to determine the owl species inhabiting the temperate forest of this park and the vegetation types where they are recorded, and to estimate their densities.

METHODS

Study site. LMNP measures 45,112 ha and is located in central Mexico (19°13'48"N, 98°01'54"W; 2650–4461 m a.s.l.; SEMARNAT 2013). Mean annual precipitation is 800 mm, with a rainy season from June to October, and a mean annual temperature of 15°C (Lara 2006). LMNP is covered by a remnant of temperate forest approximately 175 km^2 set in a landscape of ≈ 9945 km^2 of human-induced grasslands and secondary vegetation (Lara-Rodríguez *et al.* 2012). The temperate forest types in LMNP are pine forest, oak forest and mixed pine-oak forest, which cover 35%, 4%, and 2% of the area respectively (Arriaga *et al.* 2000).

The forest dominated by *Pinus* (Pinaceae) is distributed at elevations ranging from 2800 to 3600 m a.s.l., with species such as *Pinus montezuma* (the most abundant species), *P. pseudostrobus*, *P. leyophylla*, and *P. hartwegii*. This forest type is not fragmented, moderately high (30 m), dense, and often monospecific. Species of the genera *Quercus* (Fagaceae), *Abies* (Pinaceae), *Arbutus* (Ericaceae), *Alnus* (Betulaceae), *Salix* (Salicaceae), and *Buddleia* (Scrophulariaceae) can sometimes be found (Villers *et al.* 2006).

The oak forest has a mean height of 15–20 m and is located between 2650 and 2800 m a.s.l. It is dominated by *Quercus rugosa*, *Q. crassipes*, *Q. laurina*, *Q. crassifolia*, and *Q. dysophylla* (all Fagaceae), and to a lesser extent by *Buddleira parviflora*, *B. cordata*, *Cupressus lusitanica* (Cupressaceae), *Salix paradoxa*, *Alnus jorullensis, Arbutus xalapensis*, and *Juniperus flaccida* (Cupressaceae). The oak forest is highly fragmented, with remnants along roadsides and as

living fences, because seasonal agriculture has supplanted much of its natural distribution (Villers *et al.* 2006).

Existing information on the owl species inhabiting LMNP is inconsistent. Thus, local reports by birdwatchers (Windfield 2001, Fernández *et al.* 2007), and government institutions vary from four to thirteen species (CONABIO 2013, eBird 2013). From maps by Howell & Webb (1995), the possible presence of up to 10 owl species in the park can be inferred.

Fieldwork. We conducted our study from August 2005 to February 2006. Prior to our research, we established a transect of about 16 km along the perimeter road, which is in the middle of the area protected by LMNP (SEMARNAT 2013; Fig. 1). This transect was selected to cover an altitudinal gradient from 2600 to 3000 m a.s.l., where there are pine and oak forests with varying levels of disturbance. Even though the chosen transect did not cover the entire elevation range of the LMNP (i.e., 2650–4461 m a.s.l.), we consider that it was the best route that could be selected to search for owls in LMNP, because it is the longest in the area. We chose 11 fixed point counts spaced approximately 1.5 km apart along this single route (an approach followed by other owl monitoring programs; Grosshuesch & Brady 2013). We placed five point counts in oak forest, five in pine forest, and one in a mixed oak-pine forest, the latter vegetation type being little represented in the LMNP. We searched for owls (as described below) at each point. We traveled between points by car, usually at 30–40 km/h. We monitored the 11 points monthly, once per month for seven months, from 19:30 to 24:00 h, usually starting 30 minutes after sunset, always in a single direction, W to N, to visit the points (see Fig. 1). Transects were done only under favorable weather conditions; i.e. wind speeds < 20 km, no precipitation, and avoiding nights when the moon was full (Takats *et al.* 2001). Traffic within the transect was low; generally we recorded zero to one car (two cars on only one occasion) and zero pedestrians per sampled night.

To detect owl species and determine their densities, at each sampling point we listened for owl vocalizations (Takats *et al.* 2001) and audible vocal responses induced by playback. The recordings used for playback included vocalizations by species with potential distributions in the LMNP: Barn Owl (*Tyto alba*), Flammulated Owl (*Psiloscops flammeolus*), Western Screech-Owl (M*egascops kennicottii*), Whiskered Screech-Owl (*M. trichopsis*), Great Horned Owl (*Bubo virginianus*), Northern Pygmy-Owl (*Glaucidium gnoma*), Burrowing Owl (*Athene cunicularia*), Short-eared Owl (*Asio flammeus*), Northern Saw-whet Owl (*Aegolius acadicus*), and Elf Owl (*Micrathene whitneyi*) (*sensu* Howell & Webb 1995). We obtained the vocalizations used for playback from the Cornell Lab of Ornithology Laboratory (2005). We played owl vocalizations on a portable double ratio CD player (LG, model LPX-M930). We followed the American Ornitholigist' Union (1998 and supplements) checklist suggestions for owl scientific and common names.

After arriving at each sampling point we waited silently for 2 minutes. Then, for 2 minutes, we made registers of any owl vocalizations heard. Subsequently we played the sound of each of the species with potential distribution in the LMNP (see previous paragraph) for 30 seconds, with 30 seconds of silence between songs to listen for possible vocalizations in response to the vocalizations played. Playbacks of smaller species (e.g., Elf Owl) were played before those of bigger species (e.g., Great Horned Owl). At each of the sampling points, we confirmed the vocal response by different individuals (simultaneously or not) by considering the direction of the sites where they were heard. We also regis-

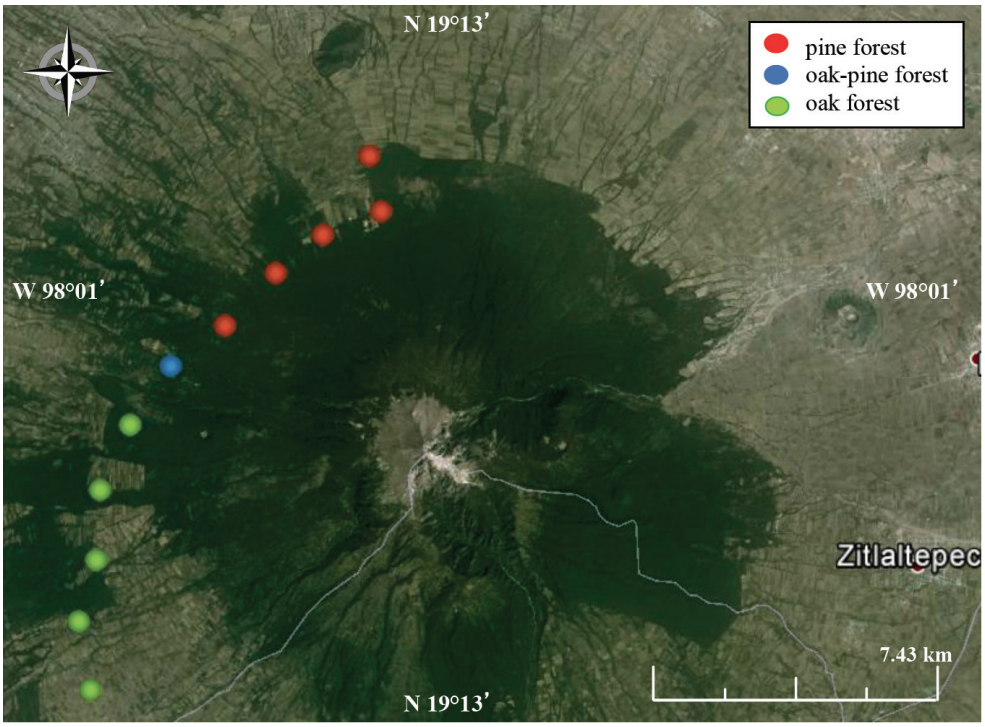

FIG. 1. Point counts where owls were searched at La Malinche National Park (LMNP), Tlaxcala, Mexico, during August 2005-February 2006. The colors of the points represents the vegetation type at the point. Image from Google Earth version 7.1.2.2041(Google Inc. 2013).

tered the estimated distance of the vocalizing bird from the point of playback. The distance from the sampling point to the vocalizing owl was judged by a single observer (ROP), who had previously had several training sessions in pine and oak forest to ensure that all field data would estimate the distance to the calling owls consistently and with reasonable accuracy. At each point we spent approximately 14–16 minutes listening for owls for a total of approximately 150 minutes of sampling effort per night, and 1050 minutes of total sampling effort in the study.

We estimated the density of owl species taking into account vocalizations/species/km^2, a common measure used with owls, using the program Distance 6.0 (Thomas *et al.* 2009), which takes differences of detectability between species into account and adjusts the density estimates accordingly. We considered detectability as the probability of detecting an individual of the target species that is already in a sampled area (Thomas *et al.* 2009). We pooled all data obtained per species and using the Distance program, used Akaike's Information Criterion (AIC) to evaluate three models (half-normal cosine, simple polynomial hazard rate and cosine hazard rate) to determine the most appropriate detection function for each owl species. We also obtained the effective detection radius, a measure of the limiting distance up to which an individual of a species can be detected with confidence in a specific habitat. This measure

is useful because when using point transects, the observer measures or estimates radial distance (r) from the point to the bird. Estimating distance to birds detected by sound, but not seen, is difficult because the attenuation of bird vocalizations is affected by vegetation type and physiognomy, position of the bird relative to the observer, and song or call pitch (Waide & Narins 1988). Under these circumstances, it is often preferable to collect data in intervals ("grouped data"). The assumption of measurement accuracy is relaxed and one assumes only that observations are placed into the correct interval (Buckland *et al.* 1993). It increases consistency among and within observers, and the effective detection radius helps to assess whether the distance intervals have been established appropriately. Here, we used four intervals bounded at 100, 200, 400, and 800 m. To estimate vocalizations/species/km^2 in LMNP, we took into account all records of each species, independently of which vegetation type they were recorded in, because there were too few records to estimate density by vegetation type. For each species we show density as vocalizations/species/km^2 ± s.d. and its coefficient of variation. We recognize that as we re-sampled the points on the transect each month, we obtained few records per species (see results) and that our low sample size affects the vocalizations/species/km^2 estimates; however, we estimate owl vocalizations/species/km^2 for LMNP to provide a baseline estimate that can be contrasted and validated by future owl monitoring studies in LMNP.

RESULTS

During the seven months of the survey, we recorded a total of 30 vocal encounters from seven species: Barn Owl (*Tyto alba*), Western Screech-Owl (M*egascops kennicottii*), Whiskered Screech-Owl (*M. trichopsis*), Great Horned Owl (*Bubo virginianus*), Northern Pygmy-Owl (*Glaucidium gnoma*), Burrowing Owl (*Athene cunicularia*), and Northern Saw-whet Owl (*Aegolius acadicus*) (Table 1). Six species were recorded in oak forest, five in pine forest, and three in mixed oak-pine forest (Table 1). The Barn Owl was heard only in oak forest while the Whiskered Screech-Owl only in pine forest (Table 1). The overall mean number of individual owls detected per night was 4.3 ± 3.1 (mean ± s.d.).

The Great Horned Owl (9 records) and the Western Screech-Owl (8 records) were the most registered species. Barn Owl and Whiskered Screech-Owl (1 record each) were the least registered species (Table 1).

The owl species differed in number of vocalizations/species/km^2 and effective detection radius (Table 2). The Western Screech-Owl had the highest (0.26) and the Whiskered Screech-Owl the lowest (0.08) number of vocalizations/species/km^2. The Great Horned Owl had the highest (852 m) and the Burrowing Owl the lowest (340 m) detection radius. The density estimates of Northern Pygmy-Owl, Burrowing Owl, and Northern Saw-whet Owl showed the highest coefficient of variation (close to 40%; Table 2), indicating that their density estimates have greater variability than those of Western Screech-Owl and Great Horned Owl.

DISCUSSION

We recorded seven owl species to LMNP. Although most of the owl species reported in our study are included in the CONABIO potential list (2013) (except Western Screech-Owl), it is clear that the seven additional species listed there merit a review for potential inclusion in the LMNP checklist.

The species not registered in our monitoring but reported by CONABIO (2013) are Flammulated Owl, Ferruginous Pygmy Owl (*Glaucidium brasilianum*), Elf Owl, Mottled Owl (*Ciccaba virgata*), Spotted Owl (*S. occidentalis*),

TABLE 1. Nocturnal raptor species registered per month by vegetation type from August 2005 to February 2006 in La Malinche National Park, Tlaxcala, Mexico. Numbers are the pooled records per month and vegetation type.

Species	Months							Vegetation type		
	A	S	O	N	D	J	F	Oak	Pine	Pine-oak
Tyto alba Barn Owl		1						1	-	-
Megascops kennicottii Western Screech-Owl		1	1	3	3	1		6	-	2
Megascops trichopsis Whiskered Screech-Owl				1				-	1	-
Bubo virginianus Great Horned Owl		2		2	1	2	1	5	4	-
Glaucidium gnoma Northern Pygmy-Owl		1	1	1	2			1	3	-
Athene cunicularia Burrowing Owl		2	1					1	1	1
Aegolius acadicus Northern Saw-whet Owl		2			1			1	2	1

Barred Owl (*Strix varia*), and Long-eared Owl (*Asio otus*). Six of these species (except the Flammulated Owl) had neither been previously reported by other studies (Windfield 2001, Fernandez *et al.* 2007) nor by isolated records (eBird 2013). However, three of these species (Flammulated Owl, Mottled Owl, Long-eared Owl) may occur in this protected area (*sensu* Howell & Webb 1995).

Of the latter species, only the Flammulated Owl has been reported by previous LMNP monitoring studies (Windfield 2001, Fernández *et al.* 2007). The Flammulated Owl breeds from April to August (Howell & Webb 1995, Holt *et al.* 1999, König & Weick 2008). It is possible that we did not record the species because we did not sample during most of that period.

We recorded Whiskered Screech-Owl and Burrowing Owl, but they have not been reported previously for LMNP, except by the CONABIO potential list (2013). We recorded the Whiskered Screech-Owl only once, in pine forest in November. The species is very secretive and does not vocalize during most of the year, which in turn reduces its chances of detection. The lack of records for the Burrowing Owl at LMNP may be because this species inhabits open areas, which are seldom included in bird-watcher visits or ornithological studies in LMNP.

At community level, at first sight our overall mean number of individual owls detected per night (4.3) is higher than that reported by other studies in temperate North American environments. Grosshuesch & Brady (2013), using a similar method (a transect traveled per night, with ten sampling points spaced approximately 1.6 km apart) reported 2.17 to 2.24 owls per night in forests in Wisconsin and Minnesota; however, they did not use vocal responses induced by playback, their sampling effort was higher (173 transects traversed by 143 volunteers), and their sampled season was shorter (15 days) than ours (7 transects traversed by 2–3 observers for 7 months).

TABLE 2. Estimates of owl vocalizations/species/km^2 for owl species inhabiting La Malinche National Park, Tlaxcala, Mexico. Estimates were obtained using Distance 6.0 program (Thomas *et al.* 2009). D = estimated density (vocalizations/species/km^2); SD = standard deviation; % CV = percent coefficient of variation (std. dev./mean * 100).

Species	D (± SD)	% CV	Effective detection radius (m)
Tyto alba Barn Owl	0.23	-	-
Megascops kennicottii Western Screech-Owl	0.26 ± 0.01	27	699.9
Megascops trichopsis Whiskered Screech-Owl	0.08	-	-
Bubo virginianus Great Horned Owl	0.24 ± 0.03	31	852.1
Glaucidium gnoma Northern Pygmy-Owl	0.13 ± 0.02	48	699.9
Athene cunicularia Burrowing Owl	0.17 ± 0.02	44	339.9
Aegolius acadicus Northern Saw-whet Owl	0.16 ± 0.01	39	555.2

At species level, there are no reports on densities of Mexican owls that can be directly compared with our study. Only three studies present data on owl density in Mexico (Young *et al.* 1998, Rodríguez-Estrella & Pelaez 2003, Alba-Zuñiga *et al.* 2009). Because their method was different our results cannot be directly compared. However, considering that a population density of 6.7 individuals/km^2 for the threatened Balsas Screech Owl (*Megascops seductus*) was used to establish it as a moderately abundant species in Morelos (Alba-Zuñiga *et al.* 2009), and a population density of 0.089 individual/km^2 for spotted owls (*Strix occidentalis luada*) ranked it as a rare species in Chihuahua (Young *et al.* 1998), our estimates suggest low population densities for the owl species in La Malinche. However, for Barn Owl and Whiskered Screech-Owl, for which we obtained only one record, the estimated densities are less reliable. The differences between their estimates (0.23 and 0.08, respectively) are due to the distance (from the sampling point to the vocalizing owl) where the individuals of each species were registered (100 m and 300 m, respectively).

Finally, we focused our sampling on the two major vegetation types in LMNP because both are important for owls. Previous studies in nearby landscapes of central Mexico have determined that these forests are highly diverse in owl species (Valencia-Herverth *et al.* 2012), and, as other authors have reported (e.g., Howell & Webb 1995, König & Weick 2008), some species show a clear tendency to occupy one or the other vegetation type. In our study, e.g., the Western Screech-Owl was recorded mostly in oak forest and never in pine forest, while its congener, the Whiskered Screech-Owl, was recorded only in pine forest.

The importance of the mixed pine-oak forest for owls in LMNP should be evaluated in future studies, because even though this vegetation type covers only 2% of LMNP and it was poorly sampled in our study, we registered three of the seven owl species there. Although LMNP is the only protected area in

the state of Tlaxcala, it hosts at least 23.3% of the owl species of Mexico (*sensu* Howell & Webb 1995). Further studies are needed to generate information about movements, behavior, food habits, breeding rates, status, and conservation of these species in the area.

ACKNOWLEDGMENTS

We thank L. A. Morales García and V. Martínez García for field assistance. This study was written while funded by Programa Estratégico de Cuerpos Académicos Calidad y Productividad para su Internacionalización (CACyPI Uatx 2013). We appreciate the improvements in English made by Margaret Schoroeder.

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