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Nest site characteristics and reproductive success of burrowing owls (Strigiformes: Strigidae) in Durango, Mexico

Ricardo Rodríguez-Estrella[1] and Alfredo Ortega-Rubio[1]
Instituto de Ecología A.P. 18-845. México 11800 D.F. México.
[1] Present address: Centro de Investigaciones Biológicas de Baja California Sur, Apartado Postal 128, La Paz 23000 B.C.S., México.

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Abstract: The burrowing owl, *Athene cunicularia,* is a threatened red species in most of its North American distribution. Nest-site characteristics and reproductive success were compared for two breeding seasons in the southern Chihuahuan desert, Durango, Mexico. Reproductive success is highly correlated with the presence of the *Prosopis-Hilaria* grassland association. The following factors were not associated with nesting success: burrow type, distance to the nearest adjacent nest, soil texture and number of perches.

Key words: *Athene cunicularia,* burrowing owls, nesting habitat characteristics, México, reproductive success.

Studies on nest-site selection by birds of prey indicate that raptors select nest sites according to physical characteristics of the habitat, such as topography and perch availability, and according to biotic features, such as ecosystem maturity, prey abundance, and interspecific competition (Southern and Lowe 1968, Bock and Lepthien 1976, Janes 1985). Burrowing owls *(Athene cunicularia)* in Canada and the United States of America generally nest in arid, open country with grasslands (Coulombe 1971, Martin 1973, Green and Anthony 1989).

Population declines have occurred in recent decades through much of the owl's range (Zarn 1974, Powers and McIntosh 1975, Collins 1979) apparently due to habitat destruction or modification and to the control of burrowing mammals (Best 1969, Butts 1973).

In Mexico, no information is available regarding the status, breeding ecology, nest-site characteristics or habitat use of this species. This study considers nest-site characteristics and reproductive success during two breeding seasons in the southern portion of the Chihuahuan desert, Mexico.

MATERIAL AND METHODS

Study area: We worked in the Mapimí Biosphere Reserve (26° 29'-26° 52' N, 103° 58'-103° 32' W). In Mapimí, 9 vegetation types have been recognized by Martinez and Morello (1977), with *Larrea tridentata, Fouquieria splendes, Prosopis glandulosa, Jatropha dioica, Agave* sp., *Opuntia* spp. and *Hilaria mutica* as dominant species.

The study area lies between 1,000 and 1,350 m elevation. Mean monthly temperature varies between a minimum of 11°C in January-February and a maximum of 28°C during summer. Precipitation is highly variable, with an annual mean of about 230 mm (Barbault and Halffter 1981). About 80% of the precipitation falls during the summer (June to September). Livestock grazing is the principal human activity in the area, but this activity apparently has not yet strongly modified the habitat (Barral 1988).

Methods: Owls and their burrows were located by intensively searching on an area of 20,000 ha from March through July in 1985 and 1986. Surveys were initially random and stand condition maps of the reserve were posteriorly used to garantee that all potential breeding habitats had been searched. Every nest burrow occupied by a breeding pair was visited at least once a week. For each nest we recorded the kind of burrow used, the surrounding vegetation type, soil texture, number of suitable perches within 40 m of the burrow, distance to permanent water, distance to the nearest occupied burrow and the number of young fledged. We classified the surrounding vegetation types into 7 minor vegetal associations dominated by different species. Soils were classified according to texture. Burrow types were classified according to the animal species having constructed them. We determined the number of young at each nest-burrow during the post-fledging period.

We tested the nature of spacing between nest-burrows using a "nearest-neighbor test" of dispersion (Clark and Evans 1954). Mean distances from one active nest to the next nearest were calculated and compared with those of a random distribution.

A Principal Component Analysis (PCA) (Conner and Adkisson 1977, Morrison 1981) was performed in order to identify the characteristics of the owl' nests most strongly correlated with used nests. We have chosen this analysis because PCA is a multivariate technique that elucidates underlying factors without any a priori assumptions. The variables chosen for further analyses were those which were most readily interpretable in a biological sense. A correlation analysis was then performed between nest site-characteristics, successful nests and number of fledglings. A x^2 test of association between the number of fledglings and the variables most correlated was then applied.

RESULTS

We found 29 nesting pairs in 1985 and 23 pairs in 1986 in the Mapimí desert region. Nesting densities were 0.15 pairs/km^2 and 0.12 pairs/km^2, respectively ($p > 0.05$, x^2 test). Although we probably did not find every nesting pair, we applied the same searching effort in each year.

Nesting success was similar in both years, 55% in 1985 and 65% in 1986 ($x^2 = 2.84$; df = 1; $p > 0.05$; Table 1). However, productivity was slightly but not significantly higher in 1986 (2.19 young per successful nest, 1.52 per attempt) compared to 1985 (1.63 young per successful nest, 0.90 young per attempt) ($p > 0.05$; t-test). Nest failure was due to abandonment (37.9% in 1985, 21.7% in 1986), predation by coyotes (3.5% in 1985), predation by badgers (4.3% in 1986), and human interference (3.5% in 1985, 8.7% in 1986). Of the burrows occupied in 1985, 16 (55.2%) were again occupied in 1986. Individual owls were not banded, so we do not know if pairs present at the same site both years were the same individuals.

TABLE 1

Summary of the burrowing owl productivity in the Mapimí desert, México

	1985	1986	Both years
No. nesting attempts	29	23	52
No. successful nests	16	16	32
No. fledglings	26	35	61
Fledglings/successful nest	1.63	2.19	1.91
Fledglings/attempt	0.9 ± 1.0	1.52 ± 1.3	1.17 ± 1.1

Tables 2 and 3 show the main features of the habitat surrounding the nests.

TABLE 2

Burrowing owl nest-site characteristics in the Mapimí Biosphere Reserve, Durango, México, 1985-1986. The mean and standard deviation are presented for each variable

	1985 (N= 29) Mean ± SD	1986 (N= 23) Mean ± SD	Both years (N= 52) Mean ± SD	Range
Distance to nearest adjacent nest[a]	1.1 ± 1.1	1.1 ± 0.9	1.1 ± 1.0	0.03-4.1
Distance to water[a]	4.1 ± 3.2	3.4 ± 1.7	3.8 ± 2.6	0.05-12.5
Number of perches	11.8 ± 5.1	11.8 ± 4.9	11.8 ± 4.9	4-20

[a] Distances are expressed in km.

TABLE 3

The association between some burrowing owl nest-site characteristics and productivity in the Mapimí Biosphere Reserve

	Number of nests		Number of fledglings	
	N	%	N	%
Vegetation type				
Larrea	3	8.3	2	3.3
Fouquieria-Larrea	5	13.9	9	14.7
Larrea-Prosopis-Agave-Fouquieria	2	5.6	3	4.9
Prosopis-Larrea	7	19.4	12	19.7
Prosopis	6	16.7	3	4.9
Prosopis-Hilaria	12	33.3	30	49.2
Fouqueria-Prosopis-Larrea	1	2.8	2	3.3
Total	36	100.0	61	100.0
Soil texture				
Clay	13	36.1	22	36.1
Clay-sand	18	50.0	33	54.1
Sand	5	13.9	6	9.8
Total	36	100.0	61	100.0
Burrow type				
Badger	6	16.7	14	22.9
Fox	8	22.2	17	27.9
Kangaroo-rat	15	41.7	15	24.6
Coyote	1	2.8	0	0.0
Desert tortoise	6	16.7	15	24.6
Total	36	100.0	61	100.0

When we performed a PCA for 1985 and 1986 habitat characteristics, the results for both years where similar, so we applied a PCA including all habitat characteristics for both years 1985-1986. The first three factors explained all 68% of the total variance in both years. We chose the factors having high weighting values for burrows used as nests (Table 4). The vegetation type, the burrow type and the distance to water, which were highly correlated in the first factor, were chosen for further analysis because they were the most important biological factors. In addition, a correlation analysis showed that the vegetation type was the only one factor most correlated with nesting success ($r = 0.5746$).

Most burrow-nests were under grassland *Prosopis-Hilaria* (33%) and *Prosopis-Larrea* vegetal associations (19%) (Table 3). Knowing that the vegetation type seems to be the main factor associated with the reproductive success, and taking into account that there are not significant differences between the data of 1985 and 1986, we combined the data (Table 3), and

TABLE 4

Results of the Principal Component Analysis performed on all variables for burrowing owl nest-sites. Factors with weights >± 0.5 are in bold

Variable	Factor 1	2	3
A Vegetation type	**0.78**	0.10	-0.06
B Burrow type	**0.51**	**0.63**	-0.05
C Distance to water	**0.78**	-0.15	-0.06
D Nearest adjacent nest	0.17	**-0.87**	-0.11
E Soil texture	-0.02	0.11	**-0.85**
F Number of perches	-0.16	0.24	**0.73**
Cumulative variance explained	25.8	47.0	68.6

found that nests located at the *Prosopis-Hilaria* grassland vegetation produced almost 50% of the total fledglings, which is highly significant ($x^2 = 7.62$; df = 1; $p < 0.01$).

These owls used five kinds of burrows. These apparently were constructed by kangaroo-rats *(Dipodomys merriami, D. nelsoni)* (41.7%), foxes *(Urocyon cinereargenteus)* (22.2%), badgers *(Taxidea taxus)* (16.7%), desert-tortoises *(Gopherus flavomarginatus)* (6.7%), and coyotes *(Canis latrans)* (2.8%). Some of the kangaroo-rat burrows could also have been constructed by ground squirrels *(Spermophilus spilosoma).* Kangaroo rat burrows were most frequently used in both years (12 of 29 nests in 1985 and 8 of 23 in 1986). A difference in the number of fledglings produced in each kind of used burrows was found ($x^2 = 9.22$; df = 3; $p < 0.05$; Table 3), all the burrow-nests having produced a similar proportion of fledglings.

Differences between years were not significant for distance to water (t-test = 0.9737; $p > 0.05$), and for the nearest adjacent nest (t-test = 0.0839; $p > 0.05$). Most nests were over 3 km from water but the distance to permanent water ranged from 50 to 12 500 m ($\bar{x} = 3806 \pm 2625$ m). The number of perches ranged from 4 to 20 ($\bar{x} = 11.8 \pm 4.9$) (Table 2). Nest-burrows were most frequently in clay and clay-sand soils ($x^2 = 11.2$; df = 2; $p < 0.01$; comparing the three kinds of soil) (Table 3).

The mean distance between adjacent owl nests were over 1 km, but ranged from 30 to 4 167 m ($\bar{x} = 1287 \pm 98$ m). The distribution of active nests in both years indicate a tendency toward regular spacing of breeding pairs ($c_{1985} = 3.04$; $c_{1986} = 3.29$; $p < 0.01$; see Clark and Evans 1954).

DISCUSSION

As in other North American deserts (California: Coulombe 1971, Thomsen 1971; New Mexico: Martin 1973; Oregon: Green and Anthony 1989), burrowing owls in the Mapimí desert nest in open habitats, called "playas". They particularly nested where elevated perches were available and their nests were associated mainly with a mixture of grassland vegetation and sparse trees.

The tendence of owls to nest in "playas" with the *Prosopis-Hilaria* association seems to be enhanced by the availability of burrows, soil texture, number of perches, low nest predation and availability of preys. All these factors may act improving the reproductive success of burrowing owls in the *Prosopis-Hilaria* association.

These owls generally use abandoned burrows of any mammal for nesting (Coulombe 1971, Rich 1984, Green and Anthony 1989). At Mapimí, they nest in a wide variety of mammal burrows, chiefly those of foxes and kangaroo-rats (or squirrels). They also nest in desert tortoise burrows. Kangaroo rat and tortoise burrows in Mapimí concentrate mainly on the bajadas and playas (Grenot and Serrano 1981, Morafka *et al.* 1981); badger and fox burrows distribute in playas and hills (J. Herrera pers. comm.). Probably, owl nest distribution in Mapimí is not related to the distribution of mammal burrows, as found in other studies (Green and Anthony 1989) as any kind of burrow is used.

In contrast with populations of the United States (Thomsen 1971, Butts 1973, Martin 1973, Green and Anthony 1989) the Mapimí owls did not often nest close to other owl nests. We observed many apparently suitable unused burrows between nest sites. This availability of nest-burrows could explain the wider nesting distribution and the regular spacing between nests in Mapimí.

Soil texture has a significant effect on the longevity of a burrow (Morafka *et al.* 1981, Green and Anthony 1989), and at Mapimí a clay-sand soil texture seems to be the principal factor influencing burrow re-use. Green and Anthony (1989) present similar findings related to soil texture and burrow re-use. However, burrow re-use in Mapimí may be also related to a good production of fledglings in the previous year (or years) (14 of 21 nest-burrows successful in 1985 were re-used in 1986), and to the small percentage of nest predation.

Preys of this owl in Mapimí were mainly insects and small mammals (Rodríguez-Estrella, unpubl. data). These preys were specially abundant in the *Prosopis-Hilaria* association (Rodríguez-Estrella, unpubl. data, Grenot and Serrano 1981).

Nesting success in Mapimí (62%) was slightly higher than the 54% in California (Thomsen 1971) and the 53% in Oregon

(Green and Anthony 1989). Productivity, measured as young fledged, was similar in the California resident population (Thomsen 1971), but was lower than the New Mexico migratory population (Martin 1973). The hypothesis of Martin (1973) which proposes that burrowing owl migratory populations have more reproductive success, seems to be supported with our results.

In this part of the Chihuahuan desert, cattle raising is the most important economic activity. It is well known that cattle raising is one of the potential causes for the loss of burrows for the owl (Howie 1980). Because of this potential conflict of interests, and in order to establish a conservation program in the Chihuahuan desert, data on the effect of the cattle density on the reproductive success of the Burrowing Owl is needed.

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RESUMEN

La lechuzita de madrigueras, *Athene cunicularia,* es una especie amenazada en la mayor parte de su distribución en Norte América. Las características de los sitios de anidamiento y el éxito reproductivo fueron comparados durante dos estaciones reproductivas, en la porción sur del Desierto Chihuahuense, Durango, México. El éxito reproductivo está altamente correlacionado con la presencia de la asociación vegetal de *Prosopis-Hilaria.* Los factores que no estuvieron asociados con el éxito reproductivo fueron: el tipo de madriguera, la distancia al nido ocupado más cercano, la textura del suelo y el número de perchas.

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