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Analysis of mammal remains from owl pellets (*Tyto alba*), in a suburban area in Baja California

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Abstract

We analysed 108 owl pellets of the barn owl, *Tyto alba*, collected daily in winter, from December 1998 to March 1999. Pellet analysis gave us the opportunity to study variation in daily diet relative to effects of lunar phases, and to evaluate owl preference for rodents in urban or rural areas. The nest was in a suburban area, 200 m from a large arroyo and 400 m west of a densely occupied city. The diameter of each pellet was measured with a caliper (0.01 mm precision) and the specimens were stored in individual paper bags. Each pellet was disaggregated into its components to evaluate the biomass of the prey. As indicators, we used skull, pelvic, and long bones. The average dry weight of pellet was 5.0 ± 1.8 g, and the average of number of specimens per pellet was 2.58 ± 1.5 (1–7). Of 282 rodent skulls, 74.4% were of Heteromyidae family 11.3% of Muridae, and 14.3% of Geomyidae. Plant and insect remains (55.5% and 9.2%, respectively) were also present. Sub-adult rodents were present in 61.9% of the pellets, and rural rodents composed 83.3% of the prey. The average daily biomass of food consumed was estimated at 55.7 ± 33.5 g (12–152). During the full moon, we found fewer rodents (18.8%) and that represented a smaller portion of biomass (19.4%) compared to other lunar phases. These long-term data showed that heteromyid rodents were most frequently consumed, especially *Chaetodipus arenarius*. Hurricane Isis appears to have had an extraordinary impact on heteromyid rodent reproduction. The results show a higher-than-normal density of juveniles and sub-adult prey in the pellets. The low number of species from the urban area can be explained by human activity, mainly by the presence of electric power lines that cause accidents to owls. Fourier series analysis showed major feeding events every 8 days, during which an increase in biomass per pellet was detected. These facts confirmed that

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Tyto alba is an opportunistic species that preys mainly on small rodents of 7–24 g and eats only necessary number of rodents to cover biomass requirements.

Keywords: Heteromyidae; Owl pellets; Predation; Lunar cycle; Suburban area

1. Introduction

Studies on fauna found in owl pellets are not very common in north-western Mexico, and the greater part of the studies focuses on the general description of the fauna found. For this reason, the chronology, which shows variation in diet by day, month, or lunar cycle, is difficult to analyse. Owl pellets give information about small vertebrate fauna, mainly mammals, of a particular area because the structure of the prey community near the nest is reflected in owl pellets (Twente and Baker, 1951; Smith et al., 1972). Studies like these have been made all over the world, but information for desert areas in north-western Mexico is very scarce (Anderson and Nelson, 1960; Anderson and Long, 1961; López-Forment and Urbano, 1977).

On 11 December 1998, we found a *Tyto alba* nest on an Indian Laurel tree (*Ficus nitida*) in a residential area near La Paz, Baja California Sur, Mexico. This was an opportunity to focus on variation in owl diet during a winter period on a daily basis, to see the qualitative and quantitative effects of lunar phases on diet and to evaluate the preference of the owl for rodents of urban or non-urban habitats. This was contrast to other papers that review large quantities of pellets, but without knowing the time duration.

2. Study area and methods

The study was conducted in a new suburban development, 7 km west of La Paz, Baja California Sur, Mexico. The nest was in the garden of a house, 6 m above the ground on an Indian Laurel (*Ficus nitida*). The nest (no offspring were seen) is about 1 km south of the shore of Bahia de La Paz and 200 m east of a very large arroyo covered with mesquite (*Prosopis articulata*). There has been no significant flooding during the past 10 yr because the arroyo was modified and channelized. The region has an arid tropical climate (Wiggins, 1980). The flora has arid and subtropical elements, with an abundance of cacti and arid zone scrubs. The most representative families are Euphorbiacea, Cactaceae, and Leguminosae (León de la Luz et al., 1996). Zoogeographically, the locality is in an arid subregion of the Llanos de Magdalena biotic province (Álvarez-Castañeda et al., 1995). Families of small mammals known to occur in the area include: 2 Phyllostomidae, 5 Vespertilionidae, 1 Molossidae, 1 Soricidae, 1 Sciuridae, 4 Heteromyidae, and 2 Muridae (Cortés-Calva and Álvarez-Castañeda, 1997; Alvarez-Castañeda and Patton, 1999, 2000).

Owl pellets were collected one per day, from 11 December 1998 to 28 March 1999, which was the last day that the owl returned to the tree. Each pellet was placed individually in a paper bag, collection date written on the outside, and the bag and contents were frozen until the sample was measured and dissected for studying diet components. In the laboratory, each pellet was weighed, and the greatest length, greatest width, and smallest width were measured with a caliper (0.01 mm accuracy). Each pellet was disaggregated into its components for species identification. We compared the remains to specimens in the mammal collections of Centro de Investigaciones Biológicas del Noroeste CIBNOR and a key (Álvarez and Álvarez-Castañeda, 2000). For differentiation of *Chaetodipus arenarius* and *C. spinatus*, the hairs found in the pellets were examined for the presence of a blister (feature that can be used to differentiate *C. spinatus* from *C. arenarius*). The absence of a blister and the knowledge that *C. arenarius* is more abundant in the area than *C. spinatus* led us to consider all small *Chaetodipus* sp. as *C. arenarius*. For plant identification, we used the CIBNOR herbarium and for insects, the CIBNOR entomological collection.

Sex determination was not done because we did not have sufficient rump bones (Moyer et al., 1984). The age of Heteromyidae and Muridae were determined on the basis of molar teeth (Koh and Peterson, 1983). For *Thomomys*, we used skull symphyses and skull morphology (Daly and Patton, 1986). For the determination of prey biomass, we used the presence of skull, rump, and long bones, as well as estimating the number of prey per pellet. If the owl fed on prey without eating bones, error would be introduced into the results. For this reason, we report the minimum prey per pellet. Prey weight was extrapolated by comparison with specimens collected in the area and archived in the CIBNOR mammal collection.

To measure rodent density, we used data for the same months from two previous long-term studies of areas to the west of this collection location. One is an undisturbed natural area located near La Paz, in El Comitán (24°05′N, 110°21′W) and the other a disturbed area at Brisamar (24°11′N, 110°30′W), a few kilometers further west. In these two relatively natural areas, the mark-and-recapture method was used on 5 nights in each month of the study, which lasted more than 5 years (Cortés-Calva and Alvarez-Castañeda, 2003). There were two trapping grids, each covering a 70 m × 70 m area containing 49 Sherman traps at intervals of 10 m.

Analyses of variation for the 95% frequency were made with Mann–Whitney *U* and *G* tests. Other analyses were made, including regression, multiple regressions, ANOVA, Duncan's multiple range test as a post hoc comparison, and Fourier series (Statistica, 1995). For correlation with the lunar period, we used the standard four phases: first quarter, full moon, third quarter, and new moon.

3. Results

We examined 108 owl pellets collected each day between 11 December 1998 and 28 March 1999. Statistical averages were: dry weight, 5.0 ± 1.8 g with coefficient of variation (c.v.) 0.37; greatest length, 43.4 ± 9.9 mm, c.v. 0.23; greatest width, 26.8 ± 3.9 mm, c.v. 0.15; smallest width, 20.3 ± 2.8 mm, c.v. 0.14; and minimum prey per pellet 2.58 ± 1.5 (range 1–7). One prey was found in 31 pellets (28.7%), two were found in 28 (25.9%), three prey in 25 (23.1%), four in 11 (10.1%), five in 7 (6.4%), six in 4 (3.7%), and seven in 2 (1.8%).

Rodent skulls were found in all pellets (282 skulls from 3 different families): Heteromyidae in 74.4% of the pellets, Muridae in 11.3%, and Geomyidae in 14.3%. Plant material was found in 60 pellets (55.5%). The most abundant were Graminacea (47.2%) and Fabacea (6.9%). Insects were found in 10 pellets (9.2%), most commonly Gryllidae (4.6%; Table 1).

Rodents of the Heteromyidae family are significantly ($g = 500$, df. = 5, $p < 0.01$) a more common prey and are the most important in biomass ($t = 3.0$, df. = 16, $p < 0.05$), with 3299 g (54.3%), compared to Muridae (2060 g, 33.9%) and Geomyidae (711 g, 11.7%). No significant difference was found between the last two families in the frequency of predation and biomass. *C. arenarius* accounted for 26.4% of the biomass and the genus *Chaetodipus* for 54.5%. The bulk of the biomass (98.5%) was composed of *Thomomys bottae*, *C. baileyi*, *C. arenarius*, and *Mus musculus* (Fig. 1).

Out of these four species, *C. arenarius* was the most common prey ($n = 143$, $\chi^2 = 173.0$, df. = 5, $p < 0.01$), followed by *C. baileyi* ($n = 87$), *T. bottae* ($n = 33$), and *M. musculus* ($n = 25$), without significant differences between the last three species. A compilation of identified species is shown in Table 1.

There were significant differences in the number of *C. arenarius* and *T. bottae* collected in different months. For *C. arenarius* results are: frequency ($F_{(3,104)} = 4.06$; $p < 0.009$) biomass ($F_{(3,104)} = 3.32$; $p < 0.022$), and the least numbers were obtained in March. For *T. bottae* results are: frequency ($F_{(3,104)} = 5.75$; $p < 0.001$) and biomass ($F_{(3,104)} = 4.89$; $p < 0.003$). For *C. baileyi* ($F_{(3,104)} = 1.51$; $p < 0.217$) and ($F_{(3,104)} = 1.29$; $p < 0.282$). For *M. musculus* ($F_{(3,104)} = 0.85$; $p < 0.468$) and ($F_{(3,104)} = 0.89$; $p < 0.448$). No significant differences occurred in the latter two species (Fig. 2).

Sub-adults were preyed on significantly more often (61.9%) than adults. Results are: *C. arenarius* ($\chi^2 = 74.8$, df. = 3, $p < 0.01$), *C. baileyi* ($\chi^2 = 69.3$, df. = 3, $p < 0.01$), *M. musculus* ($\chi^2 = 14.0$, df. = 3, $p < 0.01$), and *T. bottae* ($\chi^2 = 74.8$, df. = 3, $p < 0.01$). No data are available for *D. merriami*, *N. lepida,* and *Rattus rattus*.

Analysis showed that urban rodents (*M. musculus* and *R. rattus*) were found in 15.7% of the pellets and native rodents (*C. arenarius*, *C. baileyi*, *D. merriami*, and *N. lepida*) were found in 83.3% of the pellets, a significant difference of ($z = 9.32$, df. 214, $p < 0.01$). Geomyidae rodents were not used in this analysis because they have a homogeneous distribution in both areas.

Average biomass consumed per day was assessed at 55.7 ± 33.5 g (12–152) for all rodents. Without gophers, the average was 42.8 ± 24.8 g (12–120). It follows that gophers make a significant difference ($g = 290$, df. = 93, $p < 0.01$) in the biomass of the pellets. Minimum rodent specimens found per day in the pellets were estimated as: 1.5 for small rodents, 0.8 for medium rodents, and 0.3 for large rodents. Calculated biomass of pellets varied from 12 to 158 g/day over 108 days, and a periodicity was observed. For this reason, a spectral analysis using Fourier series was performed and a period of 7.71 days was found, with a shorter secondary period of 13.20 (Fig. 3).

The long-term study by Cortes-Calva and Alvarez-Castañeda (2003) showed that *C. arenarius* were more commonly captured in the natural preserve (El Comitan) and

Table 1
Frequency and relative frequency of species found in the barn owl pellets

	Frequency	Percent frequency	Relative frequency	Percent relative frequency
Mammals				
Heteromyidae				
C. arenarius	72	66.67	143	38.65
C. baileyi	52	48.15	87	23.51
Dipodomys merriami	1	0.93	1	0.27
Geomyidae				
T. bottae	24	22.22	33	8.92
Muridae				
M. musculus	16	14.81	25	6.76
Neotoma lepida	2	1.85	2	0.54
R. rattus	1	0.93	1	0.27
Plants				
Graminae				
Bouteloua aristidoides	17	15.74	17	4.59
Erichloa lemonii	4	3.70	4	1.08
Brachiaria sp.	7	6.48	7	1.89
Sorghum sp.	3	2.78	3	0.81
Cenchrus ciliaris	2	1.85	2	0.54
Not identified	18	16.67	18	4.86
Compositae				
Perityles sp.	1	0.93	1	0.27
Fabacea				
Acacia farneciana	1	0.93	1	0.27
Cercidium praecox	1	0.93	1	0.27
Lysiloma divaricata	1	0.93	1	0.27
Calliandra sp.	1	0.93	1	0.27
Desmanthus sp.	1	0.93	1	0.27
Pithecellobium undulatus	1	0.93	1	0.27
Errazuriza megacarpa	1	0.93	1	0.27
Polugonaceae				
Boerhaavia sp.	1	0.93	1	0.27
Solanaceae				
Lycium sp.	1	0.93	1	0.27
Physalis sp.	1	0.93	1	0.27
Plant, unidentified	6	5.56	6	1.62
Insects				
Grillidae				
Gryllus sp.	5	4.63	5	1.35
Phasmidae				
Diapheromera sp.	2	1.85	2	0.54
Elateridae				
Alaus sp.	1	0.93	1	0.27
Tenebrionidae				
Dermestes sp.	1	0.93	1	0.27
Acrididae				
Trimerotropis sp.	1	0.93	1	0.27

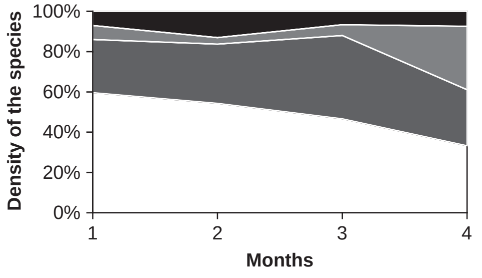

Fig. 1. Frequency of the four main species in the owl pellets, from December 1998 to March 1999. Values are adjusted to the numbers of days per month. *C. arenarius* (white), *C. baileyi* (vertical lines), *T. bottae* (horizontal lines), and *M. musculus* (black).

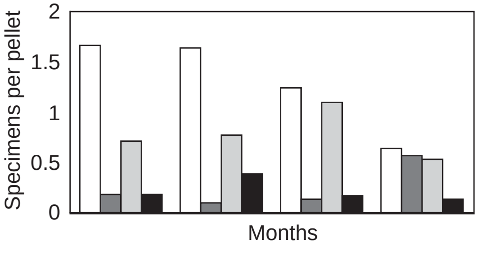

Fig. 2. Analysis of specimen per pellet per month with Duncan's multiple range test. *C. arenarius* (white), *C. baileyi* (vertical lines), *T. bottae* (horizontal lines), and *M. musculus* (black).

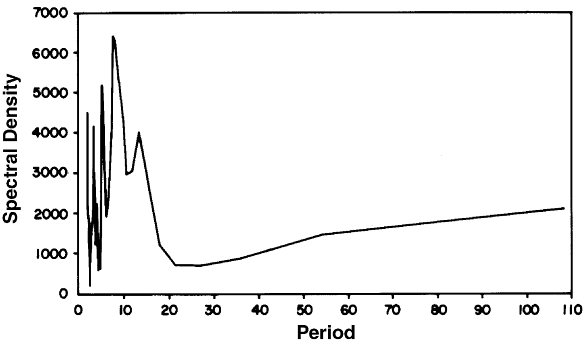

Fig. 3. Fourier series spectral analysis of the biomass of 108 owl pellets, in which the highest amplitude peak has period 7.71 days, and a secondary peak has period 13.20.

grazed (Brisamar) areas, followed by *C. baileyi*. Although less hunted in both areas, *Peromyscus eva* was more frequently taken in the natural preserve. *Dipodomys merriami* and *Ammospermophilus leucurus* were found only in the grazed area. Specimens of *Notiosorex crawfordi*, *C. spinatus*, or *Neotoma lepida* were not collected

Table 2
Prey distribution and biomass by lunar phase

	Full moon	Last quarter	New moon	First quarter
C. arenarius	25	45	40	37
C. baileyi	15	18	26	21
M. musculus	7	8	8	5
N. lepida	1	0	0	1
R. rattus	0	1	1	0
D. merriami	0	0	0	1
Minimal number of specimens	48	72	75	65
Minimal biomass	865	1112	1232	1294
T. bottae	5	5	6	9
Number of specimens	53	77	81	71
Minimal total biomass	1285	1542	1779	2105
Frequency	36	46	47	38
Percent frequency	0.21	0.27	0.28	0.22

T. bottae is separated because it is not a night-foraging rodent (frequency and percent of frequency is based on rodents found in barn owl pellets).

in these two areas in these four months. For all species, a high proportion of juvenile and adolescent specimens were found in the long-term study.

In this study, lower numbers of rodents per pellet (18.8%) and lower biomass (19.4%) were found during the full moon phase, but neither was significantly different from the others phases ($F_{(3,293)} = 0.67$; $p < 0.5$; $F_{(3,293)} = 0.34$; $p < 0.7$) and the highest number of rodents (28.8%) and greatest biomass (27.1%) occurred during the new moon (Table 2). No significant differences were observed in the numbers of prey and biomass between moon phases for the four collected species: *C. arenarius* ($F_{(3,104)} = 1.02$; $p < 0.3886$; $F_{(3,104)} = 0.84$; $p < 0.4763$), *C. baileyi* ($F_{(3,104)} = 0.55$; $p < 0.6518$; $F_{(3,104)} = 0.48$; $p < 0.6943$), *T. bottae* ($F_{(3,104)} = 0.16$; $p < 0.9205$; $F_{(3,104)} = 0.11$; $p < 0.9536$), and *M. musculus* ($F_{(3,104)} = 0.38$; $p < 0.7645$; $F_{(3,104)} = 0.36$; $p < 0.7804$). If data for *Thomomys*, which is not a nocturnal species, is removed, there would be no change in the proportions of specimen numbers and biomass among lunar phases (Table 2).

4. Discussion and conclusions

The pellets indicate that barn owls in this suburban area of La Paz area feed on rodents. No bats, birds, or reptiles were found, as recorded in other parts of the peninsula (Banks, 1965; López-Forment and Urbano, 1977). The large populations of a few species may explain why 80% of specimens in the owl pellets were *Chaetodipus* sp. Colvin et al. (1984) and Jorgensen et al. (1998) reported that the barn owl has a preference for some species over others. The insectivorous, which were very difficult to capture with traps, were abundant in the pellets (López-Forment and Urbano, 1977; Pesaturo et al., 1989). In the Valley of Mexico, López-Forment (1997) record 26.7% of diets are insectivores. In the La Paz area, one *N. crawfordi* was collected in a pitfall 20 km west of La Paz (approximately 13 km from the owl's nest, but no record of this species occurs in these pellets), but no specimens were recorded in the owl pellets Hernandez (1997) found that *Notiosorex* is not common in owl pellets.

An explanation for the absence of the field mouse, *P. eva,* in the pellets is that this species is more common in natural areas where succulents are densely spaced, thereby denying the barn owl access during flight, and because *P. eva* spend a great part of their time under very rough scrub branches (personal observation). Probably the barn owl is not exceptionally capable of monitoring of inconspicuous small mammal population (Baker, 1991).

Seeds were present in proportions related to the presence of heteromyids (pocket mice) in the pellets. We suspect that the seeds were in the cheek pockets of the rodents. Insect fragments may possibly be a part of the rodent diet. There is no evidence that the barn owl fed on plant or insect parts.

The presence of gophers in the pellets is notable because they are an underground species with supposedly low activity on the surface. Specimens collected by us show that January and February are the end of the gophers' reproductive period, and that the number of juvenile pocket gophers greatly increases in March. Probably this age group disperses at the surface to new areas during the night (Patton, 1999) or during the dusk hours when barn owl activity begins Daly and Patton (1986), therefore, being more vulnerable to predation at time of dispersion. Another explanation for juvenile pocket gophers in the pellets is that adult gophers are too large (100 g) for the 300- to 500-g barn owl (Andrews, 1990). Campbell et al. (1987) found that 73.4% of prey collected by barn owls weigh between 51 and 80 g, and Marti (1974) found the prey to be between 20 and 50 g. Owls may choose juveniles over adults. For the area of La Paz, 88.9% of the specimens collected were between 7 and 24 g, which is less than previously recorded.

The data of the long-term study (5 yr) show that heteromyid rodents were the most abundant in the area and the population was above the normal numbers, especially of *C. arenarius*. The likely reason was the more-than-average rainfall (241 mm), caused by Hurricane Isis (spring 1998). For that reason, an extraordinary reproductive explosion occurred in the entire rodent population. At the end of 1998 and beginning of 1999 an abnormally high density of juveniles and sub-adults were recorded. This effect was shown in the pellets, with over 54% of specimens of this species. Rodent species collected less often in the trapping grids were those found less often in the pellets. The above normal abundance of rodents was probably the reason that only rodents were found in the pellets.

The significantly low number of prey remnants from the urban area in the pellets can be explained by the presence of human activity, most notably electric power lines, because in the last 10 yr, 5 barn owls that had been hurt by power lines were received by CIBNOR. Another possibility is the large number of cats, which prey on the owl (Fanon, 1989). Jorgensen et al. (1998) believes that barn owls have a hunting area preference, so it might use a suburban area for nesting and fly to an adequate hunting area. Another fact is the result of the tramping surveys in the urban areas in which specimens of *M. musculus* and *R. rattus* were absent; the most plausible explanation for this is the desert condition and the absence of free water.

Analysis of the species in the pellets shows that the number of specimens and biomass of *C. arenarius* decreased over the period of study, but the numbers for *T. bottae* increased. The long-term study showed that the population of *C. arenarius* was lower in the winter, and increased from March onward (Cortes-Calva and Alvarez-Castañeda, in press). This is inconsistent with the decrease in the number of *C. arenarius* in the pellets, at least that of *T. bottae*, which is associated more with open areas and was abundant during the period of study.

The Fourier series spectral analysis showed that the barn owl had a major feeding event every 8 days, indicated by an increase in the biomass per pellet, so we surmise that the feeding strategy of the barn owl cannot be the same every day. These events support the idea that it did not feed on preferred species, but rather its feeding habits are more opportunistic, and the owl responded to its need for an increase in biomass to compensate for the deficient period.

Clarke (1983) reported that owls are more effective predators when illumination is present, but Brown et al. (1988) said that rodents may use light as an indirect cue of predatory risk. However, we did not observe a significant decrease in the number of specimens per pellet during the full moon. Kotler (1984) reported that quadruped rodents have a strong response to light, shifting habitat use and decreasing activity. Brown et al (1988), in a closed experiment with barn owls, showed that *Chaetodipus* shifted activity away from risky open microhabitat when illumination was present.

López-Forment (1997) noted that many authors emphasize the importance of smell and taste of different prey species, but others think that *Tyto alba* is opportunistic (Hernandez, 1997), but direct calculation and simulations indicate that more single-species pellets contained large mammals than would be expected from random sampling (Yoram and David, 1997). Our data of *Chaetodipus* shows larger populations of juveniles and sub-adults during the ENSO event, which are the main prey of the owl, but when the dispersion season of juvenile and sub-adult *Thomomys* began, its numbers increased in the pellets. Our own current analysis shows that *Tyto alba*, as in other areas, is an opportunistic species. Yoram and David (1997) found that they do not hunt on some species preferentially, and that the contents of the pellets may be biased towards larger prey. A long-term study for longer-time and with increased number of specimens needs to be undertaken. For the La Paz region, owls prey mainly on small rodents of 7–24 g, eats the number necessary to cover its necessary energy needs, and probably does not select between large and small prey.

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References

Álvarez, T., Álvarez-Castañeda, S.T., 2000. Clave para la identificación de ordenes, familias, géneros y especies de mamíferos del noroeste de México. In: Álvarez-Castañeda, S.T., Patton, J.L. (Eds.), Mamíferos del Noroeste de México II. Centro de Investigaciones Biológicas del Noroeste, La Paz BCS, México, pp. 831–861.

Álvarez-Castañeda, S.T., Patton, J. L., 1999. Mamíferos del Noroeste de México I. Centro de Investigaciones Biológicas del Noroeste, La Paz, BCS, Mexico, pp. 1–589.

Álvarez-Castañeda, S.T., Patton, J. L., 2000. Mamíferos del Noroeste de México II. Centro de Investigaciones Biológicas del Noroeste, La Paz BCS, México, pp. 590–877.

Álvarez-Castañeda, S.T., Salinas-Zavala, C.A., De Lachica, F., 1995. Análisis biogeográfico del Noroeste de México con énfasis en la variación climática y mastozoológica. Acta Zoológica Mexicana 66, 59–86.

Anderson, S., Nelson, C.E., 1960. Birds and mammals from barn owl pellets from near Laguna, Chihuahua. Mexico. Southwestern Naturalist 5, 99–101.

Anderson, S., Long, C.A., 1961. Small mammals in pellets of barn owl from Minaca, Chihuahua. American Museum Novitiates 2052, 1–3.

Andrews, P., 1990. Owl Caves and Fossils. British Museum of Natural History, Cromwell Road, London, 231pp.

Baker, R.H., 1991. Mammalian prey of the common barn owl (*Tyto alba*) along the Texas coast. Southwestern Naturalist 36, 343–347.

Banks, R.C., 1965. Some information from Barn Owl pellets. Auk 82, 506.

Brown, J.S., Kotler, B.P., Smith, R.J., Wirtz II, W.O., 1988. The effects of owl predation on the foraging behavior of heteromyid rodents. Oecologia 76, 408–415.

Campbell, R.W., Manuwal, D.A., Harested, A.S., 1987. Food habits of the common Barn Owl in British Columbia. Canadian Journal of Zoology 65, 578–586.

Clarke, J.A., 1983. Moonlight's influence on predator/prey interaction between short-eared owls (*Asio flammeus*) and deermice (*Peromyscus maniculatus*). Behavior Ecology Sociobiology 13, 205–209.

Colvin, B.A., Hedgal, P.L., Jackson, W.B., 1984. A comprehensive approach to research and management of common barn-owl population. In: McComb, W. (Ed.), Proceedings of Workshop on Management of Nongame Species and Ecological Communities. University of Kentucky, Lexington, pp. 270–284.

Cortés-Calva, P., Álvarez-Castañeda, S.T., 1997. Diversidad de roedores en zonas de bahía de la Paz, Baja California Sur. In: Urban, R.J., Ramírez, M. (Eds.), La bahía de La Paz: investigación y conservación. Universidad Autónoma Baja California Sur and Centro Interdisciplinario de Ciencias del Mar, Institute of Oceanography, La Paz BCS, México, pp. 265–272.

Cortés-Calva, P., Alvarez-Castañeda, S.T., 2003. Rodent density anomalies in scrub vegetation areas as a response to ENSO 1997–98 in Baja, California Sur, Mexico. Geofísica Internacional 42, 1–5.

Daly, J.C., Patton, J.L., 1986. Growth reproduction, and sexual dimorphism in *Thomomys bottae* pocket gophers. Journal of Mammalogy 67, 256–265.

Fanon, Y., 1989. A litter of wild cats *Felis silvestris* in a Tawny Owl nesting box. Aves 26, 54–56.

Hernandez, C.J.J., 1997. La alimentación de *Tyto alba* en la ciénega de Chapala, Michoacán, México. In: Arroyo Cabrales, J., Polaco, O.J., (Eds.), Homenaje al profesor Ticul Álvarez. Colección científica, Instituto Nacional de Antropología e Historia, México, pp. 157–174.

Jorgensen, E.E., Sell, S.M., Demarais, S., 1998. Barn owl prey use in Chihuahuan desert foothills. Southwestern Naturalist 43, 53–56.

Koh, H.S., Peterson, R.L., 1983. Systematic studies of deer mice *Peromyscus maniculatus* Wagner (Cricetidae, Rodentia) analysis of age and secondary variation in morphometric characters. Canadian Journal of Zoology 61, 2618–2628.

Kotler, B.P., 1984. Risk of predation and the structure of desert rodent communities. Ecology 65, 689–701.

León de la Luz, J.L., Coria, R.B., Cruz-Estrada, M., 1996. Fenología floral de una comunidad árido-tropical de Baja California Sur, México. Acta Botánica Mexicana 35, 45–64.

López-Forment, W., Urbano, G., 1977. Restos de pequeños mamíferos recuperados en regurgitaciones de Lechuza, *Tyto alba*, en México. Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoología 48, 231–242.

Marti, C.D., 1974. Feeding ecology of four sympatric owls. Condor 76, 75–81.

Moyer, A.C., Adler, G.H., Tamarin, R.H., 1984. Regressions of skull and molar measurements for estimating body size of *Microtus breweriand*, *Microtus pennsylvanicus* from southeastern Massachussets. American Midland Naturalist 133, 388–389.

Patton, J.L., 1999. Family Geomyidae: Pocket gophers. In: Wilson, D.E., Ruff, S. (Eds.), The Smithsonian Book of North American Mammals. Smithsonian Institute, Washington D.C., USA, pp. 157–174.

Pesaturo, R.J., Manning, R.W., Knox Jones Jr., J., 1989. Small mammals captured by Barn Owls in Lamb County, Texas. Texas Journal of Sciences 41, 433–434.

Smith, D.G., Wilson, C.R., Frost, H.H., 1972. Seasonal food habits of barn owls in Utah. Great Basin Naturalist 32, 229–234.

Statistica, 1995. Statistica Version 5.0. Statsoft, Inc., Tulsa, USA.

Twente, J.W., Baker, R.H., 1951. New records of mammals from Jalisco, Mexico from barn owl pellets. Journal of Mammalogy 32, 120–121.

Wiggings, I.L., 1980. Flora of Baja California. Stanford University Press, Palo Alto, CA.

Yoram, Y., David, W., 1997. Do the contents of barn owl pellets accurately represent the proportion of prey species in the field? Condor 99, 972–976.