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Food habits of nesting Ferruginous Pygmy-Owls in southern Texas.—Although Ferruginous Pygmy-Owls (*Glaucidium brasilianum*, hereafter referred to as FEPO) are listed as endangered in Arizona and threatened in Texas, only anecdotal accounts exist regarding their food habits (Bendire 1888, Bent 1938, U.S. Fish and Wildlife Service 1994). In conjunction with natural history studies on FEPOs of southern Texas (Proudfoot 1996), we collected data to profile the food habits of this species. We incorporated prey remain analysis, visual observation, and information obtained from video recordings to address several aspects of FEPO food habits (i.e., behavior and diet). However, because of the extreme variations between sampling techniques (i.e., sampling biases), we did not conduct comparative analyses.

Study area and methods.—We conducted research within a 29,000-ha live oak (*Quercus virginiana*)-honey mesquite (*Prosopis glandulosa*) forest on the Norias Division of the King Ranch, Kenedy County, Texas (26°37′30″ and 26°51′30″N, 97°27′30″ and 97°27′30″W), and within 750 ha of >80-year-old honey mesquite thicket on the Knapp Ranch, located 32 km S.W. of the Norias. The climate is subtropical with 68 cm mean annual precipitation and 24°C mean annual temperature. We collected prey remains from eight FEPO nest sites (two in 1994, three in 1995, and three in 1996) postfledging and analyzed them for identifiable prey species. Identification of prey remains was made using dichotomous keys (Jones and Manning 1992, Chaney 1993), university reference collections, and by consulting mammalogists, herpetologists, and ornithologists from Texas A&M University-Kingsville. Numbers of prey items in remains were estimated using standard procedures (Rosenberg and Cooper 1990). However, our inability to distinguish many insect remains (e.g., wing scales) limited this study. Thus, to avoid distorting the results, speculations on numbers of unidentified insects in prey remains were not recorded.

Observation blinds were established about 4 m from four FEPO nest cavities (two natural, two nest boxes). From blinds, observers recorded species and number of prey items brought to the nest cavity by adults. Because FEPOs are primarily diurnal (Gilman 1909, Burton 1973) observations were made between sunrise and sunset post-incubation to fledging (Marti 1987). To ensure sampling all of the FEPOs daily activity, observations were conducted in 3–4 h intervals that alternated among morning, mid-day, and evening.

Video footage obtained from inside active nest boxes ($N = 2$) was used to enhance food habit studies. Two replacement nest box covers were constructed to house miniature video cameras and a light source. In one replacement cover (19 × 20 × 2 cm), a 1.9-cm-diam hole was drilled through the center and a depression 6.0 × 5.5 × 1.9 cm was hollowed around the hole to house a color video camera (XC-42 Computar, Chugai Boyeki Corp., New York, New York). Two 12 V DC miniature lamps (Archer, Radio Shack, Kingsville, Texas) were then similarly installed 3.9 cm on opposite sides of the camera lens. Similarly, a second replacement cover was drilled in the center and hollowed (3.2 × 3.2 × 1.9 cm) to house a smaller black and white video camera (EM200L38 Computar, Chugai Boyeki Corp., New York, New York). One 12 V DC miniature lamp was installed in the second replacement cover to provide light.

During 1994, infrared phototransistors (Archer, Radio Shack, Kingsville, Texas) powered by a 1.5 V DC battery replaced the miniature lamps as a light source to record night activities. Video camera and light source were protected from weather by sealing the edge of the depression with silicon and attaching another hollowed board over the depression. Video patch cables (Radio Shack, Kingsville, Texas) transferred the video image to Canon A1 Digital cam-corders (Canon Inc., Japan) placed in the blind. The power source (i.e., 12 V car battery) provided >40 hrs of use. Replacement covers were installed on active pygmy-owl nest boxes (one in 1994, one in 1995) 7–10 days before nestlings fledged. Video recordings were analyzed for identifiable prey items and compared to information obtained from visual observations and prey remains.

Results and discussion.—Because the frequency of prey species in a raptor's diet is not directly correlated to its nutritional value (Southern 1954), recent studies have used mean biomass to estimate a prey's dietary importance (Marti 1974, Holt and Leroux 1996). However, if raptors consume more juveniles than adults, or more females than males in sexually dimorphic species, mean biomass estimates will distort nutritional values (Steenhof 1983). In addition, because caloric values (cal/g) may differ significantly between prey species (i.e., Northern Cardinal [*Cardinalis cardinalis*] 6020 cal/g, Northern Mockingbird [*Mimus poly-*

glottos] 5490 cal/g) (Cummins Wuycheck 1971), biomass estimates may not be an accurate interpretation of nutritional value. Therefore, lacking the information (i.e., biomass and caloric values of all FEPO prey items) and resources needed to conduct an intensive diet study, we recorded FEPO feeding behavior, frequency of prey deliveries, and prey species to profile the food habits of this owl.

Results.—Thirty-six prey species from five Classes (Amphibia, Aves, Insecta, Mammalia, and Reptilia) were identified during this study (Table 1). Information obtained from prey remain analysis indicated that mammals, birds, reptiles, and insects respectively, comprised 8.6, 10.5, 22.5 and 58.0% of the FEPO's diet. Information obtained from visual observation indicated birds, mammals, reptiles, and insects respectively, comprised 9.1, 10.3, 18.2, and 62.0% of FEPO prey deliveries. Analysis of video recording indicated birds, reptiles, and insects respectively, comprised 2.3, 7.1, and 89.7% of the FEPO's prey deliveries. Amphibians and mammals comprised <1% of video taped FEPO prey deliveries.

Throughout incubation, and for at least the first week posthatch, observations revealed that males collected all the food for females and young. During incubation, most arrivals at the nest site followed ritualistic behavior. On approach to the nest site, males called with a short series of two or three notes. After alighting on a branch near the nest site the male would repeat the two- or three-noted call, and following the second set of calls the female would emerge from the nest cavity, join the male on his perch, appropriate the prey, and fly off to feed, cache the prey (N = 3), or enter the nest cavity. Alterations from this behavior entailed the male entering the cavity to deposit prey, after announcing his approach. On four occasions (once at one nest and three times at another nest), copulation was observed between males and females after food deliveries. On three occasions, 1–4 days pre-fledging, two adult males were observed appropriating large prey items (e.g., Pyrrhuloxia [*Cardinalis sinuatus*]) provided to nestlings by adult females.

At three weeks posthatch, both adults were observed bringing prey into the nest site, however, adult males were not recorded distributing meals of prey to nestlings. Video recordings showed three peak activity periods: 07:30–08:30, 14:30–15:30, and 19:30–20:30 (Fig. 1). Analysis of video recordings indicated intense brood competition over prey items deposited by adults and over meals disbursed by adult females. In one nest that hatched five eggs, brood competition resulted in siblicide of the youngest and smallest nestling at 18 days posthatch.

Discussion.—Our results were similar to those reported by Solheim (1984) for Eurasian Pygmy-Owls (*Glaucidium passerinum*) and support anecdotal accounts of FEPO feeding behaviors (Johnsgard 1988); FEPOs are generalistic predators. In addition, cataloging hispid cotton rat and Eastern Meadowlark (*Sturnella magna*) in the diet of FEPOs lends validity to anecdotal reports of FEPOs taking prey larger than themselves (Bendire 1888, Bent 1938). Information obtained from analysis of video recordings (i.e., time of prey deliveries) substantiates anecdotal reports that FEPOs are primarily diurnal foragers (Bent 1938). We hypothesize that the peak activity periods in FEPO prey deliveries may be the effect of prey behavior and nutritional need. In the early morning hours, passerines are preoccupied with courtship and feeding, diurnal reptiles and insects emerge from cover and enter open areas to thermoregulate, and small mammals become conspicuous, increasing susceptibility to predation. Coincidentally, because FEPOs were not recorded feeding at night, we hypothesize that the nutritional needs of FEPOs may be at their peak in early morning. Hence, increased prey susceptibility coincides with nutritional need of FEPOs. Thermoregulation and nutritional requirements may contribute to the mid-afternoon peak in FEPO prey deliveries. Although many birds and small mammals seek cover in the mid-day heat of southern Texas, diurnal reptiles and insects in the forest increase their foraging activity to meet increased metabolic requirements. Consequently, mid-day foraging of reptiles and insects

TABLE 1

NUMBER OF PREY ITEMS FOUND IN THE DIET OF NESTING FERRUGINOUS PYGMY-OWLS IN SOUTHERN TEXAS, SPRING 1994, 1995, AND 1996

Prey	Number and Frequency of Prey Identified[a]					
	PR	%	VO	%	VR	%
Narrow-mouth toad (*Gastrophryne olivarea*)	0	0.0	0	0.0	1	tr.
Bewick's Wren (*Thryomanes bewickii*)	2	1.0	0	0.0	0	0.0
Blue Grosbeak (*Guiraca caerulea*)	1	tr.	0	0.0	0	0.0
Brown-crested Flycatcher (*Myiarchus tyrannulus*)	4	2.0	0	0.0	0	0.0
Eastern Meadowlark (*Sturnella magna*)	1	tr.	1	1.3	0	0.0
Pyrrhuloxia (*Cardinalis sinuatus*)	3	1.4	2	2.6	2	1.6
Nashville Warbler (*Vermivora ruficapilla*)	0	0.0	1	1.3	0	0.0
Northern Cardinal (*Cardinalis cardinalis*)	1	tr.	0	0.0	0	0.0
Northern Mockingbird (*Mimus polyglottos*)	1	tr.	0	0.0	0	0.0
Cicada (Cicadidae)	0	0.0	1	1.3	0	0.0
Click-beetle (Elateridae)	6	2.9	0	0.0	0	0.0
Cone-nosed blood sucker (Reduviidae)	9	4.3	0	0.0	2	1.6
Dragonfly (Aeshnidae)	0	0.0	0	0.0	1	tr.
Grasshopper (Acrididae and Tettigoniidae)	102	48.8	15	19.5	77	61.1
Lightning bug (Lampyridae)	3	1.4	0	0.0	0	0.0
Preying mantis (Mantidae)	0	0.0	0	0.0	1	tr.
Round-headed katydids (Phaneropterinae)	1	tr.	0	0.0	3	2.4
True katydids (Pseudophyllinae)	0	0.0	5	6.5	7	5.6
Walking stick (Heteronemiidae)	1	tr.	0	0.0	0	0.0
Common evening bat (*Nycticeius humeralis*)	1	tr.	0	0.0	0	0.0
Hispid cotton rat (*Sigmodon hispidus*)	2	1.0	2	2.6	0	0.0
Hispid pocket mouse (*Chaetodipus hispidus*)	0	0.0	2	2.6	0	0.0

TABLE 1
CONTINUED

Prey	Number and Frequency of Prey Identified[a]					
	PR	%	VO	%	VR	%
House mouse (*Mus musculus*)	1	tr.	0	0.0	0	0.0
Northern pygmy-mouse (*Baiomys taylori*)	7	3.3	0	0.0	0	0.0
Texas kangaroo rat (*Dipdomys compactus*)	3	1.4	2	2.6	1	tr.
Four-lined skink (*Eumeces tetragrammus*)	2	1.0	0	0.0	0	0.0
Ground Skink (*Scincella lateralis*)	6	2.9	8	10.4	4	3.2
Great plains skink (*E. obsoletus*)	3	1.4	0	0.0	0	0.0
Keeled earless lizard (*Holbrookia propinqua*)	2	1.0	0	0.0	0	0.0
Rose-bellied lizard (*Sceloporus variabilis*)	7	3.3	1	1.3	0	0.0
Six-lined racerunner (*Cnemidophorus sexlineanius*)	2	1.0	0	0.0	0	0.0
Texas horned lizard (*Phrynosoma cornutum*)	2	1.0	0	0.0	0	0.0
Texas spiny lizard (*S. olivaceus*)	9	4.3	0	0.0	3	2.4
Texas spotted whip-tail (*C. gularis*)	1	tr.	0	0.0	1	tr.
Unidentified insects	NR	NR	27	35.1	22	17.5
Unidentified reptiles	13	6.2	5	6.5	2	1.6
Unidentified mammals	3	1.4	2	2.6	0	0.0
Unidentified birds	9	4.3	3	3.9	1	tr.

[a] PR = prey identified from remains obtained from eight Ferruginous Pygmy-Owl nest cavities; VO = prey identified from visual observation at four Ferruginous Pygmy-Owl nest sites, included 105 h 4 min of viewing; VR = prey identified from analysis of video recordings obtained from inside two active Ferruginous Pygmy-Owl nest boxes, included 104 h 3 min of video footage; tr. = trace; NR = not recorded.

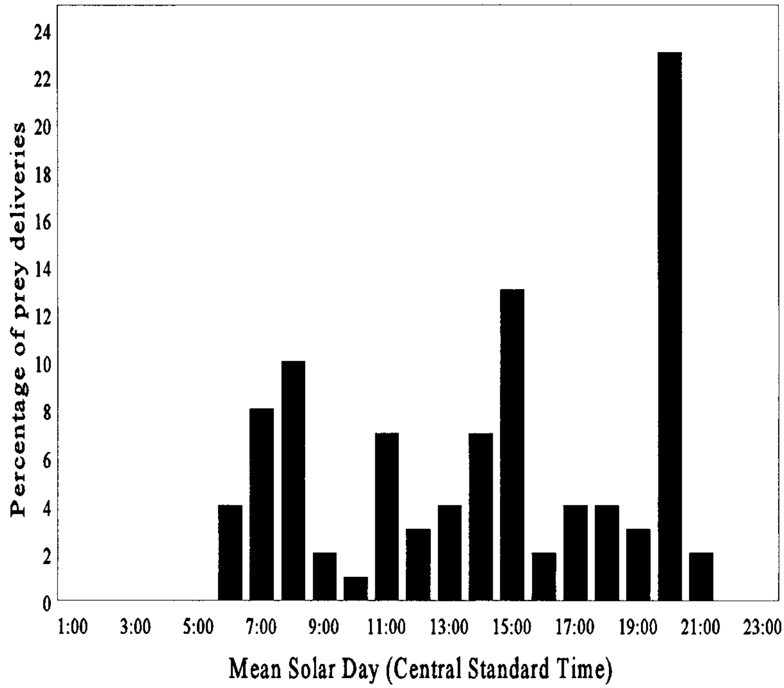

FIG. 1. Daily feeding activity at one Ferruginous Pygmy-Owls nest site in southern Texas, based on analysis of 48 h of video recording and prey deliveries.

increases their availability and susceptibility to predation. With a readily available food source, FEPOs may forage at libitum to meet mid-afternoon nutritional needs. Another hypothesis regarding afternoon peak activity may entail prey caching. FEPOs may execute excessive foraging during early morning hours and cache prey to meet mid-afternoon nutritional needs. We hypothesize that the evening peak may be attributed to the emergence of small mammals during periods of dim light, increasing availability and susceptibility of prey to predation; reductions in visual acuity of birds, reptiles, and insects in dim light, increasing susceptibility to predation; and the increased nutritional need of sustaining a brood of FEPOs through the night.

As both a primary and secondary food source (i.e., food for FEPOs and FEPO prey [passerine birds and lizards]), insects may play a pivotal role in the diet of FEPOs, although caloric values are unknown. The drought of 1995 resulted in drastic reductions in large insect (i.e., Orthoptera) numbers on the study area between 1995 and 1996 (pers. obs.). This coincides with reductions in FEPO hatching, fledging, and production efficiency (i.e., all fledglings/all eggs) (Proudfoot unpubl. ms). Although coincidental occurrence could account for these reductions, the possible negative affect of reduction or elimination of a single prey class in the diet of FEPOs warrants consideration.

This study emphasizes the importance of multifaceted food habit studies by demonstrating the significance of prey remains analysis and the benefits video recordings and visual observations have in obtaining behavioral information (e.g., brood competition, adults appropriating prey from nestlings to initiate fledging, and prey caching). Solheim (1984) recorded Eurasian Pygmy-Owls in Norway caching prey in nest cavities during winter and attributed this behavior to their small body size and higher metabolic rates relative to other owls. In addition, Solhiem (1984) hypothesized caching and retrieval of prey items suggests extended memory and possibly learned behavior. Because we observed similar behavior in FEPOs, this information may benefit future evolutionary studies of this species.

To conclude, our results suggest that FEPOs are generalistic predators and may not be influenced by the availability of any single species. However, this study failed to address areas of research (i. e., significance [caloric value] of prey species in the diet of FEPOs) essential for describing the impact of forest and resource management practices on this species. Therefore, before management guidelines are drawn, we suggest a more intensive FEPO diet study be conducted.

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The significance of fishing by Northwestern Crows.—Fishing by crows has been reported anecdotally in a few cases, specifically in the Carrion Crow (*Corvus corone*) (Dunn 1985) and Northwestern Crow (*C. caurinus*) (Shepherd 1988). We describe here the behavior in greater detail and suggest that intertidal zone fishing provides a significant source of nutrition to Northwestern Crows during limited, but predictable foraging periods. On two occasions we have observed large groups of Northwestern Crows fishing systematically for Pacific sand lances (*Ammodytes hexapterus*) buried in sandy areas at very low tides.

The first observations were made on 25 August 1996 between 08:08 and 08:45 PST at Meadowdale Park Beach, north of Seattle, Washington on Puget Sound. The tide height ranged from .03 m above to −0.2 m below mean low tide during this period. The birds demonstrated a distinctive behavior of flipping sand to each side with their beak while digging a 5–8 cm hole in the sand. This usually resulted in the bird pulling out a silvery slender fish approximately 150 mm in length. The birds held the fish sideways in their bills initially, then set the fish on the sand, reoriented the fish lengthwise and swallowed it whole. This behavior was observed in the majority of birds on the beach at that time, numbering from 36 to 41. Three specific birds were observed for 10 minute focal samples, documenting their behavior both prior and subsequent to the capture of one of these fish. These observations indicated that a crow could find and handle a fish in less than five minutes. One of those three birds lost its prey to a conspecific: scrounging (intraspecific theft [Vickery et al. 1991]) was observed at high rates during periods of fishing. Gulls also took sand lances from crows and were never observed digging for the fish themselves.

The second observation period was on 28 August 1996 between 10:20 and 11:23 PST at Meadowdale Park Beach. The tide height during this period ranged from 0.1 m above to −0.3 m below mean low tide. Again, a large majority of the 28 birds on the beach were observed to perform this behavior, though it only occurred in this narrow window of time and tide height. We observed 12 "scrounges" of sand lances during this period. Again, gulls took fish from crows and were not observed searching or digging for fish.

We eventually obtained one of the fish by running up to birds who were digging but had not yet obtained their fish. This sample was confirmed as a Pacific sand lance (*Ammodytes hexapterus*). The high rate of both intra- and interspecific theft suggested to us that the sand lances were highly valued by both crows and gulls. We were particularly interested in the value of a fish in satisfying a crow's daily energy requirements. The average daily energy requirement of a 285g crow (Pyle et al. 1987) can be estimated at 403.7 kJ/day (Walsberg 1983). The average length of a sand lance is 15.5 cm with a caloric content of 22.52 kJ/g-dry weight (Vermeer & Devito 1986). We converted the average length into wet weight (Vermeer & Devito 1986) and converted wet weight to dry weight (0.29 g-dry/g-wet; Cooper 1978). This resulted in a value of 120.1 kJ/fish. In a similar fashion, the energy content of intertidal worms, a frequent intertidal food item (pers. obs.), (average dry-weight: 25mg) was calculated to be 0.42 kJ/worm (Goss-Custard 1977a, 1977b). Thus, the average crow needs only 3.4 sand lances/day to satisfy their daily energy requirements, whereas they would need 961.2 average-sized worms. Clearly these fish provide a valuable energetic