INSECTS PREDOMINATE IN PEREGRINE FALCON PREDATION ATTEMPTS IN ARIZONA

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ABSTRACT: We compare two methods of collecting data on food habits (observations of predation attempts [*n* = 131] and analysis of prey remains at eyries [*n* = 809]) for Peregrine Falcons (*Falco peregrinus*) in Arizona. White-throated Swifts (*Aeronautes saxatalis*) were pursued in at least 38% of the predation attempts on birds but constituted 22% of the avian diet (by number) from prey remains. Insects constituted 1% of prey remains from eyries but were targets in 69% of observed attacks on prey. Insects, primarily cicadas (Cicadidae), were especially important numerically to breeding females guarding their nest cliffs. These observations suggest that insects may be much more important than formerly supposed in the Peregrine Falcon's diet in other regions when and where large insects are aloft.

Our intent in this study was to document, from observations of hunting attempts, the importance of insects and birds in the diet of Peregrine Falcons (*Falco peregrinus*) in Arizona. In prey remains from Peregrine Falcon eyries in Arizona (Ellis et al. 2004), birds constituted 98% of 809 prey; insects constituted only 1% by number. Even while compiling data for that study, however, we were aware that we had seen insects being pursued much more frequently than the prey remains suggested.

Three previous studies hint that insects sometimes make up a considerable portion of the Peregrine's diet. In 116 stomachs from North America reported by Snyder and Wiley (1976), 20% of the prey items by number were invertebrates. Also, 14% of the regurgitated castings analyzed by Ritchie (1982) from the Yukon River region of Alaska contained insects. More generally, White and Brimm (1990) mentioned scores of cicada (Cicadidae) remains at one eyrie and some grasshopper (Orthoptera) remains at other Peregrine eyries, all in Australia. But how many of the insects in these studies were consumed as gizzard or crop contents of avian prey?

Treleaven (1977:68), Parker (1979:111), Sherrod (1983:47–50), and Dekker (1999:34) reported that recently fledged Peregrines often hunt aerial insects. White and Brimm (1990) saw a yearling Peregrine capture 11 locusts (Orthoptera) in 8 minutes in Fiji. Young falcons of other species also hone their hunting skills on insects (e.g., Beebe 1950). Later, young falcons graduate to avian prey.

By contrast, our observations of Peregrines capturing insects were exclusively of adults. Treleaven (1998:226) also observed a resident adult female Peregrine catching insects in the air in southern England. In Colorado, an incubating female Peregrine ate migrating Mormon crickets (*Anabrus simplex*) as they swarmed past her on the eyrie ledge (Craig and Enderson 2004:36).

Bats were also under-represented in the Arizona prey remains—totally undetected by Ellis et al. (2004)—but have long been known to be prey of Peregrines in the American Southwest (Stager 1941, Constantine 1948, Glinski 1998, and White et al. 2002). We have also seen Peregrines in Arizona hunting bats. Various authors have noted that mammalian prey go under-detected unless regurgitated pellets are examined (Bradley and Oliphant 1991), but, to avoid other biases, in our earlier paper (Ellis et al. 2004) we did not include pellets in our study of prey remains.

To complete our review of the literature on Peregrine Falcon food habits for Arizona, we note nine other published accounts. Two of these are probably based on observations in Arizona (Tibbits 1990; Glinski 1998). Two others, although purporting to discuss the Peregrine in Arizona, probably based their statements on food habits on what was then known of Peregrine diet elsewhere (Eaton and Smith 1937, Phillips 1947). Limited data on food habits are also available for Arizona from two studies of stomach contents (Fisher 1893, Swarth 1904). White et al. (2002) also listed 20 prey taken in the Grand Canyon of the Colorado River. A few other minor sources for data on food habits were cited by Ellis and Monson (1989) and include pursuit of three ducks, one each of the Killdeer (*Charadrius vociferus*), Mourning Dove (*Zenaida macroura*), and White-throated Swift (*Aeronautes saxatalis*). Ellis (2006) described tactics used by Peregrines to hunt swifts.

Finally, we made an additional 10 observations of Peregrines with prey for which the pursuit was not witnessed. These include three Mourning Doves (plus one additional Mourning Dove and one Band-tailed Pigeon [*Patagioenas fasciata*] observed by Jay H. Schnell), one each of the White-throated Swift and Red-winged Blackbird (*Agelaius phoeniceus*), and five cicadas.

METHODS

From 1975 through 2006, we recorded all observations of Peregrines' predation attempts. Most observations were incidental to our efforts to determine occupancy and productivity at known eyries or to locate new eyries (Ellis 1982, 1988), so most are for the breeding season. A few were from wetlands where prey concentrated. Observations were aided by binoculars and/or telescopes.

In addition to the observations we report here as predation attempts, we also accumulated many observations of Peregrine Falcons attacking ravens (*Corvus corax* and *C. cryptoleucus*), Golden Eagles (*Aquila chrysaetos*), hawks (*Buteo* sp.), Turkey Vultures (*Cathartes aura*), and Prairie Falcons (*F. mexicanus*). Because such attacks have more to do with territorial defense and displacement activity than with predation, none were tallied in this study.

RESULTS

Our list of 131 observed pursuits (Table 1) demonstrates the importance of insects and White-throated Swifts. At least 15 of 40 (38%) attacks on birds were on swifts. Stated differently, 15 of 32 (47%) attacks on identifiable birds were on swifts. We suspect that most or all of the attacks on unidentified small

Table 1 Observations of Peregrine Falcon Predation Attempts in Arizona, 1975-2006[a]

	Adults: breeding[b]		Fledged young[c]		Immature[d]		Adults: non-breeding		
Prey	CA[e]	SA[f]	CA	SA	CA	SA	CA	SA	Subtotal attempts
White-faced Ibis (*Plegadis chihi*)	1F				1F				2
Large ducks (Anatidae)		1F						1F	2
Shorebirds (Charadriiformes)	2F	2F							4
Band-tailed Pigeon (*Patagioenas fasciata*)			1F						1
Mourning Dove				1F					1
White-throated Swift	2S, 3F	1S, 6F, 2U		1F					15
Flicker (juvenile; *Colaptes* sp.)	1S								1
Horned Lark (*Eremophila alpestris*)	1F								1
Swallows (Hirundinidae)		3F		3					
Pinyon Jay (*Gymnorhinus cyanocephalus*)	1F								1
Red-winged Blackbird (*Agelaius phoeniceus*)	1F								1
Unidentified sparrow-size bird		3S, 3F, 2U							8
Cicada		40S, 1F							41
Unidentified insect		36S,							50
Bird totals	3S, 9F	4S, 16F, 4U	2F	1F				1F	40
Insect totals		76S, 7F, 8U							91

[a]Attacks recorded as successful (S), failed (F), or success unknown (U). Some failed attacks likely resulted in the injury or death of the prey.

[b]Although some Peregrine Falcons occupy their breeding cliffs in Arizona year round, we define the interval for this category as 1 March–1 September.

[c]Defined as from fledging in summer to 31 December.

[d]Completely or mostly in juvenal plumage in second calendar year.

[e]CA, cooperative attack.

[f]SA, solo attack.

birds (n = 8) were also on swifts, but the distances involved were too great to be certain. In the study of prey remains (Ellis et al. 2004), swifts were also the most important bird numerically (172 of 773 identifiable birds; 22%). Only 3 of the 13 (23%) most clearly observed attacks on swifts were successful.

Although we witnessed 91 attacks on insects, we were confident of the insect's identity in only 41 attempts (all on cicadas). In our tally from prey remains (Ellis et al. 2004), only two of nine insects were cicadas. All attacks occurred high in the air (normally 200 m or more aloft). Of 71 attacks where the sex of the predator could be specified, nearly twice as many (47) were by adult females; the remainder (24) were by adult males.

DISCUSSION

The discrepancy between the importance of insects in prey remains (9 of 809 prey, 1%: Ellis et al. 2004) and their importance from observations of hunts (91 of 131 predation attempts; 69%) in Table 1 requires some explanation. First, to make a conservative tally of prey remains from eyries, we excluded insect fragments (knowing that they could have come from stomach and crop contents of avian prey) and tallied insects as prey only when we found large undamaged wings (e.g., from cicadas) or intact large hind legs (from locusts).

Second, a bias in the data from the hunting observations stems from the fact that approximately 90% of our observations were made from vantage points near eyries during the breeding season. This resulted in our being much more likely to see hunting efforts by adult females because it was the females that usually remained on guard in the immediate vicinity of the eyrie. Some of the feeding bouts on insects probably represented attempts by adult females to feed on whatever was available while awaiting the male's return with more substantial prey.

Evidence that Peregrines view insects as inferior prey comes from three observations. (1) We never saw adult male falcons deliver insects to their mates, even on the six captures when adult females were nearby. (2) We never saw an adult female solicit insect prey from her mate. By contrast, males in Arizona, as elsewhere, when arriving with avian prey, are consistently solicited by adult females with loud vocalizations and often vigorous visual displays. (3) We only once saw an insect delivered to nestlings.

All 91 attempts at insects occurred in 11 bouts. Attacks on insects were observed only when migratory or mating swarms of insects were aloft. Insects were easy prey: unlike attacks at birds, stoops at insects were never high speed or repeated. Typically a falcon made only one shallow, brief (20–100 m) stoop, followed by an insignificant upward swoop, terminated by forward thrusting of the feet to grasp the insect (Figure 1). Misses never resulted in a repeat attempt at a missed insect; rather, the falcon proceeded forward in the airstream to the next potential prey.

Rates of hunting success, based on observations whose outcome was certain, were 19% for avian prey (7 of 36 attempts) and 92% for insect prey (76 of 83), for a combined rate of 70% (83 of 119). From 16 studies evaluated by Roalkvam (1985), the Peregrine's capture success for avian prey varied from 7% to 83%. In the breeding season, hunts by adults averaged

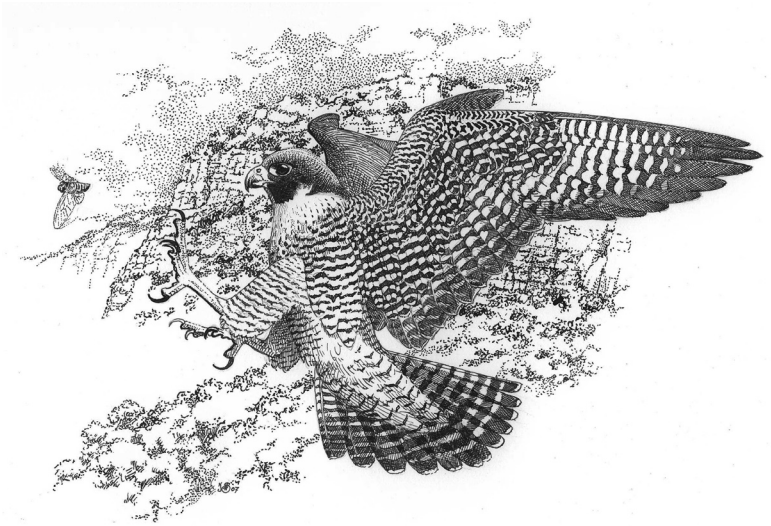

Figure 1. Adult female Peregrine Falcon pursuing a cicada.

Illustration by John Schmitt

34.9% successful; in the nonbreeding season, adults averaged 12.7% and immatures averaged 7.3% successful. There are so many variables from study to study, however (e.g., prey type, habitat type, season, level of motivation of the falcon, etc.), that cogent comparisons and clear conclusions are nigh impossible. Obviously, elusive quarry would have lower capture rates, while rates for large, less maneuverable insects, likely the easiest of all aerial prey to capture, would be much higher.

Although we have seen Peregrines approaching and/or attacking bats on several occasions, we did not include these observations in Table 1 because darkness made uncertain both the number of and the success of most attacks. Even when a predation attempt was observed from a distance of only 200 m, it proved impossible, in the fading light, to tell how many times the falcon actually tried to capture a bat as the falcon flew again and again, through and around, the swirling column. Captures were somewhat easier to count but only when the falcon flew to an observable perch and consumed the prey. It will require special equipment and a concerted effort to document bat predation adequately.

This study hints at the importance of cooperative hunting: one-third of attacks on birds by breeding adults were cooperative. The study also demonstrates how vastly different the estimates of diet can be when different methods are used: most importantly, insects represented only 1% of prey by number in remains at eyries (Ellis et al. 2004) but 69% of prey by number in observations of hunts. We suggest that quantitative observations of predation in other populations will show that insects are sometimes important to this obligate ornithophage.

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