SHORT COMMUNICATIONS

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PREDATION OF NESTING LARIDS BY PEREGRINE FALCONS AT RASA ISLAND, GULF OF CALIFORNIA, MEXICO[1]

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Peregrine Falcon (*Falco peregrinus*) diets vary widely. On the Pacific Coast of North America, they feed on petrels and alcids (*Oceanodroma, Synthliboramphus, Ptychoramphus*) (Green 1916, Brooks 1926, Bent 1938, Beebe 1960), while in the Gulf of California they take Eared Grebe (*Podiceps nigricollis*), Black Storm-Petrel (*Oceanodroma melania*), Least Storm-Petrel (*O. microsoma*), Red-necked Phalarope (*Phalaropus lobatus*), Bonaparte's Gull (*Larus philadelphia*), Heermann's Gull (*L. heermanni*) and Craveri's Murrelet (*Synthliboramphus craveri*) (Porter and Jenkins 1988).

Due to seabird coloniality, close to exclusive dependence of individual Peregrine Falcons on particular prey species may put their survival in an inverse relation to the degree of pollution of marine areas where their prey feed. In the case of Rasa Island, 95% of the population of the two main prey species nest synchronously, providing close to 300,000 prey available for three months.

In this study I determined: (1) the dietary composition of a breeding pair of Peregrine Falcons that hunted on a densely occupied seabird nesting island in the Gulf of California, Mexico, (2) the relationship between number of individuals of each seabird species and their relative consumption by a Peregrine Falcon and (3) the falcon's effect on those seabird populations.

STUDY SITE

Rasa Island, a 1,000 by 700 m flat island with a maximum altitude of 33 m is in the northern half of the Gulf of California (28°49′N, 112°59′W). It is volcanic in origin and composed of low rocky hills and valleys covered with guano. There are three tidal lagoons on the northwest side. Vegetation is scant (less than 5% cover), consisting mainly of coastal saltbush (*Atriplex barclayana*), a few patches of dense cholla (*Opuntia cholla*), a few large columnar cacti (*Pachycereus pringleyi, Stenocereus gummosus, Lophocereus schottii*) and some halophyte patches (*Heliotropium curassavicum, Salicornia pacifica, Sesuvium verrucosum*) by the tidal lagoon's shores. In 1982, about 120,000 Heermann's Gull pairs (about 95% of the world's population), 15,000 Elegant Tern pairs (*Sterna elegans*) (also about 95% of the world's population) and 8,500 Royal Tern pairs (*S. maxima*) bred on the island between March and July (Velarde 1989). Colony establishment occurred between 15–20 March.

METHODS

I searched the entire island for prey remains once a week from 20 March through 20 May 1982. Searches were done systematically following a circuit along the island's edge and along the ridges of all the hills of the island; this allowed me to view all of the hillsides and valleys below. Therefore, I assumed that all prey were found. Prey remains of Peregrine Falcons are easily identified (Craighead and Craighead 1969); pectoral muscles and entrails are totally consumed and occasionally the skull is opened and the brain consumed. Usually, only the wings attached to the scapular girdle, the vertebral column, the pelvic girdle, the legs and lower portion of the skull are left. The only other raptor present on the island was a pair of Common Barn Owls (*Tyto alba*). Over a ten-year period, the owls' diet never included adult gulls nor terns (Velarde, pers. observ.). There were no other predators on adult seabirds on the island. Other Peregrine Falcons are found on closest neighboring islands, Salsipuedes and Partida, both about 7 km (SE and NW, respectively) from Rasa Island. They do not, however, hunt on Rasa Island.

Average masses of potential prey were calculated using a sample of 64 Heermann's Gulls, 43 Elegant Terns and ten Royal Terns captured on the island. The number of nesting Heermann's Gulls was estimated for 20 randomly distributed quadrats (10 × 10 m). This value was multiplied times the surface area occupied by the gulls. Numbers of nesting Elegant and Royal Terns was estimated measuring the surface area occupied by their colonies, multiplied by the number of nests per unit area for each species, estimated from 20 randomly distributed quadrats (1 × 1 m). The relationship of number of prey consumed to available

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prey was calculated through a chi-square analysis. In the analysis I assumed that I found all prey (see above), Peregrine Falcons ate only Larids (no other prey were found), and falcons ate nowhere else (due to the presence of other falcon pairs in nearest islands).

RESULTS AND DISCUSSION

Remains of 50 adult larids were found in the 66-day period: 40 Heermann's Gulls, nine Elegant Terns and one Royal Tern. The estimated average food requirement for active adult Peregrine Falcons in Britain has been estimated as about 127 g/day, plus 20% of prey remains that are not consumed (Ratcliffe 1980). Lower estimates for North American falcons have been obtained only from captive individuals, presumably with lower energy demands. Therefore, the Peregrine Falcon pair should have consumed about 20 kg of prey in the 66 sampling days (127 g/day × 66 days × 2 birds + 20% of unconsumed prey) on Rasa Island. According to the prey remains collected on the island and the average mass of these birds, the following amounts of prey were consumed: 16 kg of Heermann's Gulls (400 g/individual × 40), 2.7 kg of terns (250 g/individual Elegant Tern × 9 + 450 g/individual Royal Tern). This totals 18.7 kg of prey consumed, which is 93.5% of the estimated requirement for a pair of falcons. This represents 86% by mass for Heermann's Gulls, 12% for Elegant Tern, and 3% for Royal Tern. The proportion in number of prey consumed of each of the three species in relation to those present (nesting population) did not differ significantly (Table 1, $\chi^2 = 4.625$, df = 2, $0.25 > P > 0.1$), indicating that falcons took prey according to their availability in the environment and apparently not according to ease of capture or any other factor (Table 1). This is in agreement with the functional response model (Hollings 1959, Oaten and Murdock 1975, Abrams 1982).

The 40 Heermann's Gulls consumed during the 66 sampling days constitute less than 0.02% of the total nesting population. The nine Elegant Terns represent only 0.03% of the nesting population.

A Peregrine Falcon chick consumes an average of 157 g of prey per day during its first year of life (Ratcliffe 1980). Heermann's Gulls are on the island for an average of four months per year. Assuming that a falcon pair in the Gulf of California produces an average of 1.6 chicks per year (Porter et al. 1988), the total mass of prey consumed should be 31 kg in four months. Therefore, an average family could consume, at most, about 0.05% of the total adult Heermann's Gull population.

Heermann's Gulls spend several weeks before egg-laying performing mass flights, at dusk when they return to the nesting areas and at dawn when leaving (Velarde 1989 and unpubl. manuscript). These mass performances, never reported for other gulls, undoubtedly facilitate nesting synchrony. Synchronous breeding by Heermann's Gulls could be a response to Peregrine Falcon predation, reducing the time in which the prey are available to the predator and reducing the probability of an individual being attacked, generating a "selfish-herd" effect (Hamilton 1971, Pulliam 1973, Hoogland and Sherman 1976, Kenward 1978). Synchronous breeding among the three seabird species also reduces individual probability of being attacked. This predation may be one of the selective forces for synchronous breeding, together with Yellow-footed Gull (*Larus livens*) predation on Heermann's Gull chicks (Velarde 1989, 1992) and food distribution in time and space (Velarde et al.).

TABLE 1. Relationship between the nesting population size and total number of individuals of seabird species preyed upon by a pair of Peregrine Falcons on Rasa Island, Gulf of California, Mexico.

Prey species	Nesting population	No. of preyed individuals	Total weight hunted (kg)
Larus heermanni	240,000	40	16.00
Sterna elegans	30,000	9	2.25
Sterna maxima	17,000	1	0.45
	$\chi^2 = 4.625$, $r = 4$, $0.25 > P > 0.1$		

Many Peregrine Falcon populations are threatened, from both illegal capture, and pollution (Anderson and Hickey 1970). Gulf of California populations, particularly those along the Baja California coast and Gulf of California islands, apparently are in better condition (Porter and Jenkins 1988). Some seabirds on which Gulf of California falcons feed may be moderately to highly contaminated with pesticides, particularly organochlorines (e.g., Heermann's Gull: DDE = 6.12 ppm; DDT < 0.1 ppm; PCBs = 1.67 ppm; Porter and Jenkins 1988). Pairs of Peregrine Falcons in the gulf are probably "specialists" on the particular prey combination in their eyrie area. For example, falcons on Isla Partida (approx. 7 km SE from Rasa Island), feed heavily on Least and Black Storm-Petrels (*Oceanodroma microsoma* and *O. melania,* respectively), the major species nesting on that island (D. W. Anderson, pers. comm.) and on gulls and terns on Rasa Island (pers. observ.). Close to exclusive dependence of Gulf of California Peregrine Falcons on seabirds for food places their survival in an inverse relation to the degree of pollution of the ocean and in direct relation to the state of their prey's populations.

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LITERATURE CITED

ABRAMS, P. A. 1982. Functional responses of optimal foragers. Am. Nat. 120:382–390.

ANDERSON, D. W., AND J. J. HICKEY. 1970. Ecological data on egg and breeding characteristics of Brown Pelicans. Wilson Bull. 82(1):14–28.

BEEBE, F. L. 1960. The marine peregrines of the northwest Pacific Coast. Condor 62:145–189.

BENT, A. C. 1938. Life histories of North American birds of prey. Part 2. Orders Falconiformes and Strigiformes. Bull. U.S. Nat. Mus. 170.

BROOKS, A. 1926. Notes on the status of the Peale Falcon. Condor 28:77–79.

CRAIGHEAD, J. J., AND F. C. CRAIGHEAD. 1969. Hawks, owls and wildlife. Dover Pub., New York.

GREEN, C. DE B. 1916. Note on the distribution and nesting habits of *Falco peregrinus paealei,* Ridgway. Ibis, Ser. 10, 4:473–476.

HAMILTON, W. D. 1971. The geometry of the selfish herd. J. Theoret. Biol. 31:295–311.

HOLLINGS, C. S. 1959. The components of predation as revealed by a study of small mammal predation of the European pine sawfly. Can. Entomol. 91: 293–320.

HOOGLAND, J. L., AND P. W. SHERMAN. 1976. Advantages and disadvantages of Bank Swallow (*Riparia riparia*) coloniality. Ecol. Monogr. 46:33–58.

KENWARD, R. E. 1978. Hawks and doves: attack success and selection in Goshawk flights at Woodpigeons. J. Anim. Ecol. 47:449–460.

OATEN, A., AND W. W. MURDOCK. 1975. Functional response and stability in predator-prey systems. Am. Nat. 109:89–298.

PORTER, R. D., AND M. A. JENKINS. 1988. Pollutants and eggshell thinning in peregrines and their prey in the Baja California region, p. 413–422. *In* T. J. Cade, J. H. Enderson, C. G. Thelander and C. M. White [eds.], Peregrine Falcon populations, their management and recovery. The Peregrine Fund, Inc., Boise, ID.

PORTER, R. D., M. A. JENKINS, M. N. KIRVEN, D. W. ANDERSON, AND J. O. KEITH. 1988. Status and Reproductive Performance of Marine Peregrines in Baja California and the Gulf of California, Mexico, p. 105–114, *In* T. J. Cade, J. H. Enderson, C. G. Thelander and C. M. White [eds.], Peregrine Falcon populations, their management and recovery. The Peregrine Fund, Inc., Boise, ID.

PULLIAM, H. R. 1973. On the advantages of flocking. J. Theor. Biol. 38:419–422.

RATCLIFFE, D. 1980. The Peregrine Falcon. Buteo Books, SD.

VELARDE, E. 1989. Conducta y ecología de la reproducción de la gaviota parda (*Larus heermanni*) en Isla Rasa, Baja California. Ph.D.diss. Universidad Nacional Autonóma de México, México.

VELARDE, E. 1992. Predation of Heermann's Gull (*Larus heermanni*) chicks by Yellow-footed Gulls (*Larus livens*) in dense and scattered nesting sites. Colon. Waterbirds 15:8–13.

VELARDE, E. MS. Comparative breeding biology of the Heermann's Gull (*Larus heermanni*) in Isla Rasa, Gulf of California, Mexico.

VELARDE, E., M. S. TORDESILLAS, R. ESQUIVEL, AND L. VIEYRA. MS. Use of seabirds as sampling agents of commercially important fish populations.

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DIRECT AND INDIRECT CONSEQUENCES OF MINK PRESENCE IN A COMMON TERN COLONY[1]

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Key words: Common Tern; predation; parental neglect; exposure; Sterna hirundo.

Colonial breeding occurs in 98% of seabird species (e..g, Wittenberger and Hunt 1985). Colonies are conspicuous, however, and as predators are likely attracted to large aggregations of individuals, predation on seabirds by various mammals is frequently cited (e.g., feral cats, *Felis domesticus,* Ashmole 1963; Ermine, *Mustela erminea,* Cairns 1985; Racoon, *Procyon lotor,* Emlen et al. 1966; Otter, *Lutra lutra,* Ewins 1985; Red Fox, *Vulpes vulpes,* Maccarone and Montevecchi 1981). While relatively few citations report predation by mink, *Mustela vison,* (e.g., Burger 1974, Olsson 1974, Folkestad 1982, Alberico et al. 1991, Burger and Gochfeld 1991), mink can be a serious threat to seabird populations. In Norway, for example, breeding of Black Guillemots (*Ceppus grylle*) currently is restricted to areas where mink are absent (Folkestad 1982). While attacks by mink on gulls and terns appear rare (Burger 1974, Dunstone and Birks 1987, Alberico et al. 1991, Burger and Gochfeld 1991), the slaughter of tern and

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