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Ecology and behavior of wintering *Falco peregrinus* (Falconiformes: Falconidae) in southeastern Brazil

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RESUMO. **Ecologia e comportamento de Falco peregrinus (Falconiformes: Falconidae) invernando no sudeste do Brasil.** Entre 1991 e 1996, foram monitorados os falcões-peregrinos (*Falco peregrinus*) que invernaram na área urbana da cidade de Santos, no sudeste do Brasil. Os falcões adultos foram observados usando os mesmos pontos de pouso, sempre em edificações, e áreas de caça repetidamente durante todo o período de estudo. Desde sua chegada em outubro, até a partida em abril, o macho e a fêmea adultos interagiram diversas vezes e apresentaram comportamento de côrte. Os falcões imaturos e adultos foram observados voando juntos e ocupando a mesma área, sugerindo que algumas famílias de falcões poderiam migrar em grupo até as áreas de invernada. As principais presas consumidas foram pombos (*Columba livia*) (80,9 %) e morcegos (11,7 %). São feitas comparações das presas consumidas em outras áreas de invernada conhecidas no Brasil.
PALAVRAS-CHAVE: ambiente urbano, área de invernada, comportamento, dieta, ecologia, Falco peregrinus, sudeste brasileiro.

ABSTRACT. Between 1991 and 1996, Peregrine Falcons (*Falco peregrinus*) wintering in the urban area of Santos city, southeastern Brazil, were monitored. Adult falcons were observed using the same perches, always on buildings, and hunting grounds repeatedly throughout the study period. From their arrival in October, to their departure in April, male and female adult falcons interacted several times and showed courtship displays. Immature and adult falcons were observed flying together and occupying the same area, suggesting that some falcon families may migrate in group to the wintering grounds. The main prey species were the Rock Dove (*Columba livia*) (80.9 %) and bats (11.7 %). Comparisons of prey items of other known wintering areas in Brazil are made.
KEY WORDS: behavior, ecology, *Falco peregrinus*, prey species, southeastern Brazil, urban environment, wintering area.

In North America, the Peregrine Falcon is a well known species, throughout its breeding range, and recently, its migration routes in the northern hemisphere (Herbert and Herbert 1965, Cade *et al.* 1968, Hunt *et al* 1975, Dekker 1980, Cade 1982, Burnham and Mattox 1984, Court *et al.* 1988). On the other hand, there is little information on wintering Peregrine Falcons in Central and South America. This is significant because some falcons spend almost half of their lives there, and some wintering areas present significant sources of organochlorine contamination for the falcons (Henny *et al.* 1982). Consequently, there is a great need for information on the species' ecology in that region.

Urban habitats are attractive both to breeding and wintering Peregrine Falcons. In both cases the Rock Dove (*Columba livia*) being their main food resource (Hickey and Anderson 1969, Cade and Bird 1990, Risebrough *et al.* 1990, Schneider and Wilden 1994). In Brazil Peregrine Falcons have been widely recorded, but only six wintering areas are currently known, all in urban areas: Salvador (12°59'S, 38°31'W), Bahia state; Rio de Janeiro (22°54'S, 43°14'W), Rio de Janeiro state; São Paulo (23°32'S, 46°37'W) and Santos (23°57'S, 46°20'W), São Paulo state; and Porto Alegre (30°02'S, 51°12'W) and Rio Grande (32°01'S, 52°05'W), Rio Grande do Sul state (Silva e Silva 1996). Observations on wintering Peregrine Falcons in Brazil were first reported from Rio de Janeiro by Sick (1960), while a later, more detailed study was conducted at Porto Alegre (Albuquerque 1984). Information on the species' ecology and behavior have been reported from other South American countries (Risebrough *et al.* 1990).

STUDY AREA

The study was carried in Santos, a city of 450,000 people, located on São Vicente Island (about 6,000 ha in area), on the coast of São Paulo state, southeastern Brazil. The annual mean temperature is 20° C, but it regularly exceeds 30° C during the summer, with common records up to 40° C. Precipitation averages 2,183 mm/yr, with no dry season, although most rain falls between December and March (RADAMBRASIL 1983).

The island is isolated from the mainland by narrow mangrove-lined channels and is dominated by urban areas, with remnant native vegetation only on the steepest slopes

of the hills at the center of the island. A park along the seven km of the beach front supports numerous Tropical Almond (*Terminalia catapa*) trees, which attract many fruit bats during the fruiting season. The city has many large buildings, particularly along the seashore, where 10-16 story buildings predominate. Another important feature of the city is its seaport, the largest in Latin America, where shipments of grains sustain huge populations of Rock Doves and Ruddy Ground-doves (*Columbina talpacoti*), important food resources for Peregrine Falcons using the area.

METHODS

Falcons located in the study area were systematically followed by foot, motorcycle or car to their perches. The habitual perches were regularly checked for falcons and their behavior recorded ad libitum (Altman 1974). Some of the most frequently used perches could be observed from my apartment, making it easy to locate the falcons. Observations were made from ground level or nearby buildings, with the aid of binoculars. Falcons were photographed whenever possible for individual recognition (individuals can be distinguished by peculiarities of their malar stripes and other distinctive plumage markings). Prey species were identified when falcons were observed hunting and via remains collected at perches. Data were gathered during five consecutive wintering seasons: 30 November 1991 to 9 April 1992, 26 October 1992 to 12 April 1993, 26 October 1993 to 13 April 1994, 21 October 1994 to 14 April 1995, and 19 October 1995 to 6 April 1996.

RESULTS AND DISCUSSION

Origins and taxonomy. Two subspecies of Peregrine Falcons, *F. p. tundrius* and *F. p. anatum* have been recorded in Brazil, with overlapping winter ranges (Silva e Silva 1996). Three males collected in Santos fit the description and measurements of *tundrius* (White 1968), and two of these, immature and adult are housed in the Museu de Zoologia da Universidade de São Paulo (MZUSP.73739 and 74338). In addition, banded individuals captured in Santos have come from the range of *tundrius*. A male, banded at its nest in Manitiisoq, Greenland (66°53'N, 50°57'W) on 5 August 1989, and later recaptured at the Chincoteague National Wildlife Refuge in Virginia, USA on 1 October 1989, was found in Santos with a broken wing on 13 January 1992 (W. Mattox pers. comm.). Another male, banded in Virginia (37°00'N, 75°50'W), USA on 2 October 1991, was recaptured at the Santos port on 26 April 1995 (Bird Banding Laboratory).

General habits. Peregrine Falcons used many perches distributed over the urban area, mostly along the beach front, the port and downtown. Summing the five seasons during which I saw three to five different Peregrine Falcons annually (table 1), 59 buildings were used (each building used by falcons was considered as a different roost, although the falcons could use different perches on it). Most perches were air-conditioners or their supports, TV and a radio antennas, ledges or sheltered spaces, windows and verandas. An adult female was mostly observed along the beach front and the port, while an adult male, apparently its mate (see below) used areas further inland. Buildings in the late construction stage (almost finished but still not inhabited) were often used as roost sites inland (they could be abandoned after they became inhabited), but all used beach front buildings were inhabited.

Most buildings used by Peregrine Falcons (78 % of records) were 9 to 16 floors high, but falcons were also observed roosting on buildings as low as three floors tall. Adult falcons tended to exhibit great site fidelity to some perches, which were repeatedly used during my study. Falcons in immature plumage did not exhibit perch site fidelity but used perches frequented by adults. On 26 January 1994 an immature male was captured and banded in one of these perches, and on 25 December 1996 was recaptured in Santos. In Rio de Janeiro some perches were reportedly used for 12 years (Sick 1997), and similar records have been reported from elsewhere in South America (Risebrough *et al.* 1990). Site fidelity in the wintering areas perhaps recalls the fact that Peregrine Falcons also show great fidelity to their nest sites, especially the males (Court *et al.* 1988). Daily activities of adult falcons appeared to be strongly influenced by temperature. On hotter days (30° to 40° C), Peregrine Falcons rested throughout the day in shaded places, grooming and sometimes sleeping, and moving to another shaded perch on the building when they became exposed to full sunlight. During the strong summer downpours the falcons could be seen on TV antennas exposing themselves to the rain and bathing. Only a few times they were observed soaring over the beach-front.

Hunting periods were usually the first hours of the morning and late afternoon to dusk. Falcons would hunt during other periods on overcast days or after a few days of continuous rain (which prevented them from hunting). At dusk the falcons flew to a roosting site. I found six of these sites along the beach-front and three inland.

Interspecific relations. The presence of a Peregrine Falcon caused a mobbing reaction by other birds similar to that described for other Falconiformes (Sick 1997). Attacks or mobbing flight directed at falcons were frequent, each bird species showing a different behavior. Blue-and-white Swallows (*Notiochelidon cyanoleuca*) flew around perched falcons, always at a distance, in groups ranging from one to 15 individuals. Great Kiskadees (*Pitangus sulphuratus*) mostly mobbed falcons at their perches by repeatedly hovering and diving at the perched falcon (up to 26 consecutive times), which would duck at each attack. Kiskadees would mob falcons either alone or in groups of up to three, acting at the same time and taking breaks between mobbing bouts. Tropical Kingbirds (*Tyrannus melancholicus*) had the same behavior, but were more agressive and sometimes nipped at the falcon. Glittering-

Table 1. Numbers of Peregrine Falcons in Santos.

Season	Individuals	Total
1991-1992	2 ad. males and 1 ad. female	3
1992-1993	1 ad. male, 1 ad. female and 1 imm. female	3
1993-1994	1 ad. male, 1 ad. female, 2 imm. and 1 imm. male	5
1994-1995	2 ad. males, 1 ad. female, 1 imm. male and 1 sub-ad. male	5
1995-1996	2 ad. males, 1 ad. female, 1 sub-ad. male and 1 imm.	5

throated Emeralds (*Amazilia fimbriata*) and Swallow-tailed Hummingbirds (*Eupetomena macroura*) would fly around the falcon, attacking it from all directions, alone or in groups of up to three. Hummingbirds, especially the Emerald, were very bold and persistent, sometimes perching on the same antenna used by the falcon. I also witnessed several species mobbing falcons together. Once six Blue-and-white Swallows started circling a perched falcon, attracting a Great Kiskadee, a Tropical Kingbird and two Glittering-throated Emeralds, which attacked it continuously until the falcon flew away, being chased for 200 m.

On 23 November 1993, at 15:00, I observed a Roadside Hawk (*Rupornis magnirostris*) flying with prey in its talons being mobbed from above by some birds. A male Peregrine Falcon joined the birds and dove on the hawk, which turned and grabbed the falcon's talons. The locked raptors fell spinning close to the ground before releasing each other and flying in different directions. An adult Peregrine Falcon was also observed chasing two Yellow-headed Caracaras (*Milvago chimachima*) at the port on 22 February 1996 at 17:30.

What might be interpreted as play behavior was witnessed twice. On 30 January 1993 at 17:25 an adult male falcon was seen hunting a pigeon at low speed, touching it four times before giving up. Also, on 7 April 1994 at 18:00, a falcon soaring over a thermal with eight Black Vultures (*Coragyps atratus*) twice approached and touched a vulture with its talons.

Intraspecific interactions. Throughout the study period the study area was occupied by a pair of adult Peregrine Falcons, plus ummated adult males and immature birds. From pictures taken from the birds, the same adult pair used the area year after year. The Peregrine pair was observed flying or perched together from their arrival to departure in 7.7 % of the observation days. On 13 February 1992, at 11:20 the male was observed calling while flying after the female. The male dropped a Rock Dove to the female, who grabbed the food in mid-air and perched atop a building to feed. The adult falcons mostly perched together on a radio antenna at a beach-front building, the highest point in the area used by the female to hunt, before engaging in chases after each other among the buildings and over the beach, before returning to the perch. This behavior was repeated up to four times in a row, usually during the afternoon. On 26 December 1993 at 16:55 the adult female perched on a ledge on a building facing the port, and 30 min later the adult male perched on the same ledge, and resting 10 m from the female, with no reaction or visible interaction. Albuquerque (1988) stated that pre-mating behavior can occur at the wintering areas, as his observations of courtship behavior in Porto Alegre show. This behavior has also been observed elsewhere in South America among wintering Peregrines (Risebrough *et al.* 1990). In Salvador, an adult Peregrine Falcon pair was observed repeatedly using the same wintering area for several years until one of the birds was killed (P. Lima pers. com.). My results in Santos agree with the previous observations, and show that some pairs stay together throughout the post breeding period at the wintering areas, even showing courtship behavior.

Immature Peregrine Falcons were occasionally observed flying or perched with adults (32 % of all observations of immatures). On 23 December 1993, an adult male, an adult female and one immature were observed perched on a ledge on a building facing the port. There is currently no proof that family groups use the same wintering areas, although it is known that such groups migrate together along the east coast of the USA (Sherrod 1983, W. Mattox pers. com.). My observations suggest that family groups may use the same wintering quarters.

More complex interactions between adult and immature falcons were recorded a few times. On 13 January 1994, at 18:30, an immature male was observed chasing an adult male 10 m above a busy traffic avenue, the immature uttering begging calls. I observed the same behavior, again involving an immature and an adult on 13 February 1994 in southern Brazil, at the town of Pelotas (31°46'S, 52°20'W), Rio Grande do Sul state. However on 15 January 1995, a sub-adult Peregrine Falcon (second year plumage) was hunting a Rock Dove when an adult falcon drove it away from the area, vocalizing. These observations suggest that, at least in my study area, adult Peregrine Falcons sometimes allow immature birds, which may be their own offspring, in their presumed winter hunting territories during their first year. For example, the immature bird I banded was captured in the same spot used the night before by an adult falcon. Nevertheless, I never observed an adult feeding, hunting with, or facilitating prey capture for a young bird.

Prey and food habits. In North America the diet of breeding Peregrine Falcons is made mostly of passerines (Cade *et al.* 1968, Burnham and Mattox 1984, Court *et al.* 1988, Rosenfield *et al.* 1995), while in Great Britain F. p. *peregrinus* prefer Rock Doves (Ratcliffe 1993). During migration other species are used as food, including waterfowl, small shorebirds (mainly sandpipers) and landbirds (Hunt *et al.* 1975, Dekker 1980). At wintering areas in South America the main prey are Rock Doves and bats in urban habitats and shorebirds and aquatic birds in wetlands (Sick 1989, Risebrough *et al.* 1990, Sick 1997).

Available informations on prey species taken by Peregrine Falcons in their Brazilian wintering areas came from four areas: Salvador (Lima 1991), Rio de Janeiro (Sick 1960, 1989, 1997), Santos (this study), Porto Alegre (Albuquerque 1984) and Rio Grande (Witeck 1988, Sick 1989, 1997) (only Albuquerque (1984) reported the numbers of each prey species). Additionally Sick (1997) observed Peregrines hunting Parakeets (*Brotogeris* sp.) in Amazonia and Lesser Golden-Plovers (*Pluvialis dominica*) in Mato Grosso.

Rock Doves are an important prey species, absent from the diet only at Rio Grande, where falcons fed mainly on shorebirds and aquatic birds, although the area is a seaport where doves are present. The presence of large wetlands rich in migratory birds close to the area may explain the falcon's diet choice there. The lack of passerine birds in the diet in all areas, except for the House Sparrow (*Passer domesticus*), is also striking.

The main prey species in Santos consumed (80.9 % of the records) was the Rock Dove (figure 1), abundant in the city especially along the seashore and the port (table 2). Similarly, Rock Doves (mostly fledglings) comprised 68.5 % of the prey records at Porto Alegre (Albuquerque 1984). Another important group used as prey in Santos were bats, with two species comprising 11.7 % of the prey records. Species unsuccessfully hunted by falcons were Blue-and-white Swallow, Shiny Cowbird (*Molothrus bonariensis*) and House Sparrows. Terns (*Sterna* sp) were persistently chased but without success (R. Seckendorff, pers. com.).

The data on prey use suggest that Peregrine Falcons specialize on a few prey species in their wintering areas. This may be a way of perfecting hunting techniques and minimizing energetic cost of hunting species whose escape behavior is unknown. The records of two captured Budgerigars (*Melopsittacus undulatus*) also suggest that

Figure 1. Wintering Falco peregrinus in Santos, southeastern Brazil, on 13 March 1993 (photo by R. Silva e Silva).

Table 2. Prey items of Peregrine Falcons at Santos, southeastern Brazil, recorded from 1991 to 1996.

Species		N	%
Rock Dove	*(Columba livia)*	55	69.6
Ruddy Ground-dove	*(Columbina talpacoti)*	1	1.3
Budgerigar	*(Melopsittacus undulatus)*	2	2.5
Plain Parakeet	*(Brotogeris tirica)*	1	1.3
Dark-billed Cuckoo	*(Coccyzus melacoryphus)*	1	1.3
Unidentified birds		11	13.8
Velvety Free-tailed Bat	*(Molossus molossus)*	7	8.9
Yellow-shouldered Bat	*(Sturnira lilium)*	1	1.3
Total		79	100

the falcons are opportunist by recognizing and capturing prey that may be more vulnerable because of their non-native status.

Foraging behavior. At Santos, Peregrine Falcons hunted in areas where Rock Doves congregated. The adult female hunted on the beach front and port area, while the male was mostly observed further inland. Hunting Peregrine Falcons perched on the highest available places, providing a good view of the vicinity. When suitable prey was located, the falcon flew after it at high speed or, in the case of perched prey species, stooped at the prey, making the capture after the bird took flight. Most prey (85 %) was captured while flying, but I witnessed the capture of a Rock Dove perched on a roof, and of another that dropped on the beach-front gardens after a stoop. All prey captured at Santos was eaten immediately, but in Rio Grande Peregrine Falcons cached food to eat one or two days after capture (Witeck 1988). Food storage was also observed in breeding Peregrine Falcons in an urban environment in Germany (Schneider and Wilden 1994). The occurrence of this behavior maybe related to the area's temperature, as prey decomposes more slowly in colder areas like Rio Grande, in southernmost Brazil, compared to more tropical areas like Santos. Captured prey was carried to often-used plucking perches, usually atop air-conditioners, windows and TV antennas. Prey was beheaded and the belly and chest feathers plucked, and the falcon fed on the pectoral muscles and some viscera. Only once, on 11 January 1995, observed an adult feeding while soaring, plucking and eating an unidentified bird.

Few complete hunting sequences were observed, as chases happened among the buildings and birds were lost from view before the outcome of the hunting flight could be determined. Of 37 capture attempts directed at birds, four (10.8 %) were successfull. In the case of bat-hunting falcons, six of 22 attempts were successfull (27. 6%). Hunting success varies widely other localities, being quite high in the breeding areas (*e.g.*, 35.8 % in England and 40 % in northern Alberta, Canada), and lowering to results comparable to mine during migration (*e.g.*, 9.8 % in central Alberta) and at some wintering areas (*e.g.*, 9.6 % in Fiji) (Dekker 1980). The inexperience of an immature was observed on 7 February 1994 when one attemped to capture a Rock Dove perched close to it on a roof by running after the pigeon, both birds running around atop the building until the falcon gave up.

Bat hunting. Although hunting of bats by Peregrine Falcons is known in South American wintering areas (Risebrough *et al.* 1990), including Brazil (Sick 1997), falcons in these areas hunted in places where large flocks of molossid bats were present (Sick 1961, Albuquerque 1984, Sick 1989). This has also been documented in New Mexico, USA (Stager 1941) and other localities.

At Santos the falcons hunted in areas where few (no more than 10) flying bats were present. A similar instance was observed at the town of Aracaju (10°55'S, 37°04'W), Sergipe state, where a Peregrine was hunting a few unidentified bats on 4 November 1994 (M. Sousa pers. com.).

An adult male was repeatedly observed at Santos in its bat-hunting routine at the beach front. Around 18:00 it would perch on the tallest building in the area (14 stories). When the bats arrived, it would single one and chase it over the estuary waters, circling over the water or perching before a new attack. These flights were made at intervals of about 1 min. Falcons stooped at bats and retreived them if they fell into the water after being struck. Some bats had one of the wings broken by the impact with the falcon, and were quickly captured on a second pass by the falcon. Captured bats were taken to a perch and completely consumed in about five min. Despite the presence of other potential prey like Rock Doves, Ruddy Ground-doves and Cayenne Terns (*Sterna eurygnatha*), this falcon ignored these, and hunted only the bats. Roberto Seckendorff who first showed me this hunting place, has observed this behavior throughout the falcons' stay in Santos (from October to April). It is likely that Peregrine Falcons hunt for bats in other areas but the behavior has rarely been noted due to the size of the study area and the short period falcons spent hunting bats each time.

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