

The King Vulture *Sarcoramphus papa* in El Salvador: an Endangered Species

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ABSTRACT

Most Mesoamerican countries have classified the King Vulture as a species in danger of extinction. In El Salvador one or two breeding pairs can be found at Parque Nacional El Imposible (PNEI) in the western department of Ahuachapán, another pair in northern Morazán and occasional transients, probably from Honduras, in northern Chalatenango and Santa Ana. At PNEI King Vulture nests have been found on the ground or in large holes in trees—Volador *Terminalia oblonga* (Combretaceae) and Ojushte de invierno *Brosimum alicastrum* (Moraceae). Movement patterns of the species at PNEI were monitored from 20 March 2001 to 20 February 2002. Such data help to pinpoint roosting, nesting and feeding sites and are indispensable for managing the species. PNEI and its buffer zones cover some 5000 ha, but the King Vultures frequently go outside the area in search of food. Breeding is successful but abundance has not increased. Some young may have wandered to nearby forested areas in Guatemala or farther into the Cordillera Costera de Apaneca-Illamatepec, but no data are available on mortality or dispersal patterns. The conservation of the King Vulture in El Salvador should be enhanced by the programme of certification of ecologically-friendly shade-coffee plantations as well as by expansion of the present Salvadoran system of protected areas and biological corridors.

INTRODUCTION

The conservation status of the King Vulture *Sarcoramphus papa* varies geographically from widespread and fairly common to rare and in danger of extinction or already extirpated (for a review, see Schlee 2000). In Mesoamerica the species has been decreasing in numbers mainly because of

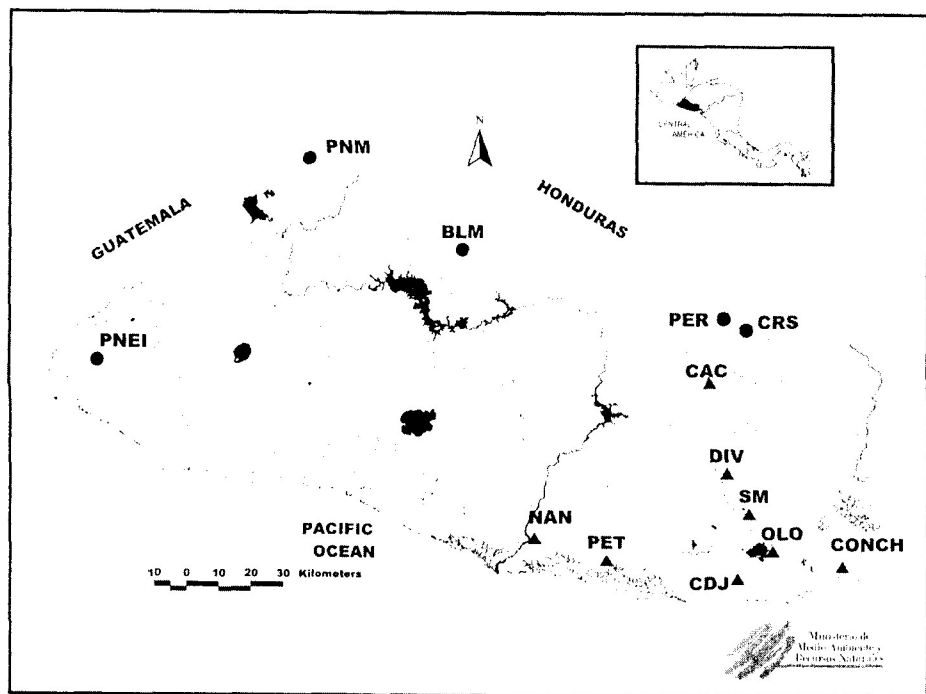
habitat destruction (Howell & Webb 1995) and diminishing food supplies (*e.g.*, Clinton-Eitniear 1987; Vannini 1989), but it has also been shot by hunters (Clinton-Eitniear 2000) and for supposedly stealing domestic fowl (Matola 1985). King Vultures are sensitive to forest fragmentation (Iñigo *et al.* 1989) and survive only if sizeable patches of primary forest remain (Stiles 1985). Between 1994 and 1998, Mexico, Guatemala, El Salvador, Honduras and Costa Rica placed the King Vulture on their official lists of species in danger of extinction and similar resolutions were underway in Nicaragua and Panama (UICN-WWF 1999). In addition, a logistic regression model used to predict extinction probabilities for Nicaraguan forest birds (Gillespie 2001) classed *Sarcoramphus papa* as critical, surpassed only by the Harpy Eagle *Harpia harpyja* and the Great Curassow *Crax rubra*.

Historically the King Vulture ranged as far north as Sinaloa on the western coast of Mexico and Tamaulipas on the eastern coast (Clinton-Eitniear 1989). At present its distribution in Mexico is centred in Los Chimalapas in south-eastern Oaxaca, the Calakmul Biosphere Reserve in eastern Campeche and in the Lacandona Forest in southern Chiapas (Clinton-Eitniear 1989; Iñigo *et al.* 1989), but the species is rare near the Yaxchilán Natural Monument (Puebla-Olivares *et al.* 2002). Accidentals have been reported near El Naranjo, San Luis Potosí (Clinton-Eitniear 2000), and at San José del Cabo Estuary in Baja California Sur some 300km from the mainland (Duncan & Lacroix 2001). The highest density of the species in Mesoamerica is currently found in northern Guatemala, the Calakmul of Mexico and the adjoining forests of Belize (Berlanga & Wood 1992). In El Salvador, as early as the 1970s, the King Vulture was cited among the lowland avian species in danger of disappearing due to the massive destruction and over-exploitation of the lowland forests as well as the high pesticide contamination coming from the cotton plantations (Daugherty *et al.* 1979; USAID 1985). In 1998 *Sarcoramphus papa* was placed on the official Salvadoran list of endangered species (MAG 1998). The aims of this paper are to (1) review the historic and present distribution, abundance and nesting of the King Vulture in El Salvador and (2) report recent observations on the species at Parque Nacional El Imposible.

STUDY AREAS

El Salvador, located in the biodiversity-rich Pacific slope region of Central America (Figure 1: insert), is home to more than 500 bird species (Komar 1998; Komar & Domínguez 2001). The country was once almost entirely forested (Daugherty *et al.* 1979) but the cultivation of indigo in the 16th century followed by coffee from the 1840s, cotton from 1945 and finally sugar cane, resulted in the disappearance of all but 2-3% of the original mature forests (Zambrana 1996). Today, 26.49% of Salvadoran territory has wooded cover of some kind, ranging from patches of dense primary forest to conifer plantations to scrub, but most are open formations; an additional 8.5% comes from shade-coffee plantations (MARN 2000a).

Figure 1. Map of El Salvador (see insert for location in Central America) marked with the main areas cited in this paper: Nancuchiname (NAN), Puerto El Triunfo (PET), Colinas de Jucuarán (CDJ), Volcán de Conchagua (CONCH), Lago Olomega (OLO), San Miguel (SM), Divisadero (DIV), Cerro Cacahuatique (CAC), Cuenca Río Sapo (CRS), Perquín (PER), Bosque La Montañona (BLM), Parque Nacional Montecristo (PNM) and Parque Nacional El Imposible (PNEI). Filled triangles denote the sites from which the King Vulture *Sarcoramphus papa* was extirpated and filled circles show the present known distribution of the species (explanations in text).



The main study area is Parque Nacional El Imposible (PNEI) located at 13°50'N and 89°58'W in the department of Ahuachapán between the municipalities of Tacuba and San Francisco Menéndez in the Cordillera Costera de Apaneca-Illamatepec. Created in 1989, PNEI is the largest protected area in El Salvador, covering some 5000ha with the buffer zones, and one of the last remaining parcels of Pacific slope forest in Mesoamerica. The most extensive forest type is the subtropical pre-montane moist forest. The terrain, ranging in elevation from 210-1425m, is extremely irregular with deeply incised valleys and precipitous slopes. The rainy season lasts mid-May to mid-October. The area is known for strong, often violent winds from the north that can reach hurricane velocities on mountain tops. PNEI is a prime example of a mosaic of forest patches surrounded by agricultural lands and small towns and villages. The vegetation in the park varies from abandoned cattle pastures, agricultural plots and coffee plantations to selectively logged forests and old-growth forests, much of the latter having been disturbed by humans. Some 50

Río Mixtepe), La Fincona (western, from Río Maishtapula to Río San Francisco) and San Francisco Menéndez (west of Río San Francisco). Most names and locations cited here correspond to those on the 1:25,000-scale maps for Tacuba (MOP 1984) and San José El Naranjo (MOP 1983). Some local usages were retained, notably for Cerro La Cumbre (Figure 2: CLC; corresponds to Cerro Puerto Arturo) and Monte Hermoso (MH) which refers to the entire massif with its savannas rather than to the cerro.

DATA COLLECTION

Observations were made at Parque Nacional El Imposible by using elevated lookouts that offered a wide angle of vision, usually on mountain peaks or ridges, as well as while walking along the network of trails for visitors or used by the park rangers to survey their respective sectors. The movement patterns of the King Vultures were studied from 20 March 2001 to 20 February 2002 to help pinpoint roosting, nesting and feeding sites. Each King Vulture sighted was counted as one detection whether it was the same bird seen at different times or a different bird. The term “sighting” comprises the total number of individuals seen together at one point in time.

The PNEI rangers, while making daily rounds in their assigned sectors, regularly take notes on animals detected visually or through faeces, tracks, etc. Many of the details reported here were taken from their personal notes, and some from unpublished internal reports that gave estimates of the frequency with which a species was detected each month. Moreover, the Raptor Monitoring Project initiated by A. Thoms (1999) in the San Benito Sector was continued by JES with the collaboration of the rangers E. Chinchilla and J.A. Quiñónez. Originally, fixed-point observations were carried out 10 days/month for three consecutive hrs (0800h-1100h or 0900h-1200h), the monitoring being rotated among the five main lookouts along the Cerro León-Cerro Pata de Gallina massifs (Figure 2: CL-CPG). Additional notes were taken on movement patterns from 1 December 2001 to 5 February 2002. MAS carried out field work at PNEI from 23 April-5 May 2001, 14-26 November 2001 and 9-20 February 2002, spending some 160 hrs in fixed-point observations (sessions ranging from 50 min to nearly 7 hrs) with additional time travelling foot paths. These data were sometimes supplemented by simultaneous reports by radio from other sectors. Additional time was spent in the gallery forests at the confluence of Río Guayapa/Quebrada Agua Prieta and north to Río El Venado; in the Montaña (Forest) El Jutal to investigate a former King Vulture nest; at Cerro Las Mercedes northwest of PNEI; at the Cara Sucia refuse dump 5-6km south-west of PNEI; in the Monte Hermoso massif south-east of the RG/QAP confluence. Another visit to PNEI took place from 25-29 January 2003. Information on the King Vulture was also collected at the Reserva Nacional Nancuchiname in the department of Usulután, Perquín-Cuenca Río Sapo in northern Morazán, Parque Nacional Montecristo in Santa Ana and in the Colinas de Jucuarán in the south-eastern departments. The data contributed by RAPL were part of a Licenciatura thesis on the local distribution of diurnal birds of prey at PNEI (Pérez León 2002). Eighteen visits of five days each were carried out in the San Benito, Campana and La Fincona sectors between 20

March and 17 August 2001. The first trail was walked from 0500h-0800h followed by observations at the lookout until 1200h, and the second connecting trail was travelled from 1500h-1800h. From 23 April-5 May, data were collected simultaneously by MAS and RAPL.

HISTORIC AND PRESENT DISTRIBUTION IN EL SALVADOR

The first detailed avifaunal survey of El Salvador took place 1925-1927 (Dickey & Van Rossem 1938), at which time the King Vulture was a fairly common resident of the eastern departments. Its centre of abundance was in the Colinas de Jucuarán—a line of rounded hills, 850m elevation at highest point, covered with dense, arid deciduous forest that extended from Puerto El Triunfo in the west to the Volcán de Conchagua and the Golfo de Fonseca in the east. The King Vultures were thought to have ranged out from the Colinas over the coastal plains where most of the large cattle ranches were located (see Figure 1 for distribution given by Dickey & Van Rossem: PET, CDJ, CONCH, OLO, SM, DIV, CAC). The species may have been present in other parts of the country, but it was not seen at the other observation or collecting stations used in the survey. MAS learned from locals at Nancuchiname that King Vultures used to be present there too (Figure 1: NAN). Rand & Traylor (1954) reiterated its presence in the south-eastern cordillera but considered the species to have been widespread in El Salvador, sometimes seen as far north as Metapán in the department of Santa Ana. When Thurber *et al.* (1987) did their study from the late 1960s to the early 1980s, the alleged sightings in the north had not been confirmed and the King Vulture had disappeared from its former range in the south-east. At that time the species was known to occur only at El Imposible (Figure 1: PNEI) and was already breeding there when the area came under study in 1976. Its historic distribution may have included the present-day sites given in Figure 1, but we found confirmation only for Parque Nacional Montecristo (PNM; see below). King Vultures have not been seen at Bosque Las Lajas in the Complejo San Marcelino Wildlife Refuge (Komar & Herrera 1995b) or at San Diego y La Barra on the shores of Lake Guija (Komar & Rodríguez 1995).

In the northern departments the species was recorded in the 1994 avifaunal surveys at Parque Nacional Montecristo (Komar & Herrera 1995a), and a lone adult was also seen during a 30-day inventory five years later, flying over the pine-oak zones located 1450-1550m a.s.l. (Komar 2002). However, MAS learned from locals and rangers that prior to the 1971-1973 reforestation of the open fields at the 1750-2000m elevations with plantations of Mexican Cypress *Cupressus lusitanica* and Ocote and Caribbean Pine *Pinus oocarpa* and *P. caribbea*, King Vultures were fairly common and regularly seen at carrion at the higher elevations. Now the species is rare and seen mainly at the middle to lower elevations, two having been sighted by a ranger at Km. 13 in early 2001. The King Vultures at PNM are probably transients from Honduras (O. Komar, pers. comm.). In the department of Chalatenango one adult, and possibly a second, was observed in July 2001 and July 2002, flying over Bosque La Montañona (Cerro El Volcancillo) about 4km from Río Sumpul on the Honduran border (O. Komar, pers. comm.). King Vultures have also been

sighted in northern Morazán near Perquín and in the Cuenca Río Sapo (Komar & Domínguez 2001): notably two adults and one black juvenile eating a dead dog at the side of a road in early 1999 (J.P. Domínguez, pers. comm.); one adult and one immature with all-white underparts in December 2000 (the young could be the same but at different plumage stages) and two adults again in July 2001 (O. Komar, pers. comm.). Park rangers at Río Sapo also indicated that 1-2 adults have been seen overhead, apparently using the area for foraging. In May 2001 MAS was shown a site near Cerro Pericón where the King Vultures were thought to have nested about three years earlier at the base of a pile of boulders near a logging road that was not in use during the war years. The adults were also seen on boulders at a higher elevation overlooking the first. Both sites had crevasses, depressions and cavities at the base of the rocks that could have been used for nesting. These reports clearly show that one breeding pair of King Vultures lives in the pine-oak forests of northern Morazán.

OBSERVATIONS AT PARQUE NACIONAL EL IMPOSIBLE

Summary of nest records

The first known nest was described in Thurber *et al.* (1987) as one egg found on the ground in 1976, location not given. The next, in January 1978, was of an adult King Vulture frightened into flight from the ground and leaving behind a dark sooty-brown nestling which scrambled away among the rocks, a grass-lined hollow under a slanting rock thought to have been the nest. Here, either the young bird was mis-identified—King Vulture nestlings are covered with white down—or it was in juvenile plumage (see descriptions in Guillén Ojeda 1989 and Schlee 1994). The citation referring to the photo taken of another egg on 2 December 1980 should read 1 January 1980 (A. Sermeño, pers. comm.) and refers to the egg found by West (1988) in a Volador *Terminalia oblonga* (Combretaceae) tree cavity on 30 December 1979 at the top of a small wooded hill along a quebrada in the Montaña El Jutal (Figure 2). The same nest was thought to have been used since 1976 (West 1988). The next known nesting at PNEI took place *ca.* 1985: the King Vultures used a horizontal cavity in a large dead limb of an Ojushte de invierno tree *Brosimum alicastrum* (Moraceae). The locals distinguish between the Ojushte de verano and the Ojushte de invierno, but at the present time the two varieties are considered to be the same species and subspecies, *B. alicastrum alicastrum* (C. Ramírez Sosa, pers. comm.). The nest tree was located near the base of the cliffs along Qda. La Cascada in the Montaña El Pacallito (Figure 2) near Río San Francisco. The King Vultures nested there only once and the limb finally fell. During the latter 1970s and early 1980s the King Vultures were also thought to have nested on the eastern-facing slopes of Cerro León (see legend to Figure 24 in Thurber *et al.* 1987), probably in the area of Las Escaleras, but this was not able to be confirmed because of inaccessibility of the cliffs as well as the lack of visibility (A. Sermeño, pers. comm.).

According to VC, the Volador in Jutal was used again *ca.* 1988. A branch broken off near the cavity left the nest more exposed and it became flooded by

the rains. In June, the chick, all-white with no black feather growth and estimated to have been 30-35 days old (determined from photos taken by MAS of captive-born young), was found sitting on a dead tree limb on the ground. When approached, the nestling vomited its food—domestic dog and possum. The rangers drilled holes in the trunk to evacuate the water, put sand in the cavity and returned the chick to the nest. The King Vultures, however, have not nested there since, but this is probably due more to the inadequacy of the site than to the disturbance. MAS and VC inspected the site in May 2001 after having seen the adults in the trees there earlier. A few small branches were in the cavity, 14.7m from the ground, but nothing indicated use by the King Vultures. The top of the hill is about 30m higher than the quebrada but the eastern and northern cliffs protect it from the winds. The tree species near the Volador were identified—Maquilishuat *Tabebuia rosea*, Ojushte *Brosimum alicastrum*, Duraznillo *Aphananthe monoica* and Níspero *Manilkara chicle*, the last three also being characteristic of mature gallery forest in the Río Guayapa/Río El Venado basin (Komar & Herrera 1995a). Finally, in 1989 or 1990 (perhaps earlier) a large nestling was found on the ground in eastern PNEI on Cerro La Olla (Figure 2: CLO). The egg may have been laid on the ground at the base of a small boulder, around which the chick had worn a path by moving about, or perhaps among the low trees nearby (E. Sandoval, pers. comm.).

Abundance and population structure

The rangers' informal reports from March 2000-January 2003 showed a mean of 12.2 detections of a King Vulture/month (range: 5-20; n = 379) and RAPL found similar values: 13.5 detections/period of 30 days (range: 5-22; n = 66). However, detection frequency increased when observations from the lookouts started by 0630h and/or lasted throughout the afternoon, MAS having recorded as many as 42 in 12 consecutive days, most not overlapping with the above data. Historically, Thurber *et al.* (1987) reported a maximum of four adult and two immature King Vultures together at carcasses—probably two family groups—and as many as eight (plumage classes not specified) had been seen by the head ranger. Nesting data also tended to indicate the presence of two breeding pairs. In 1995-1996 the maximum was still four adults, but with three young—one black but starting to have white feathers on belly and breast, another with very mottled underparts and one all-white underneath (E. Chinchilla, pers. comm.). The latter could have been 3-4 yrs old (Clinton-Eitnien 1996) or somewhat older (Schlee, unpubl.). Occasionally a subadult (mottled wing coverts) has also been seen.

In the study carried out by Thoms (1999: March through July), only three adults (no young) were reported. But in mid-February 2000, a black juvenile with some white on belly and breast, possibly remnants of down, was seen begging food from an adult (0916h) on the west side of Pata de Gallina; in the same area with 1-2 adults (*ca.* 1700h) in April/May; the family trio flying south-east of CPG in August. Six months later (28 February 2001) a family trio, probably the same, was also seen on the ridge west of Río El Corozo near Casco La Fincona (*ca.* 1700h). From 20 March 2001-20 February 2002, 64.7% of the reported sightings were of a lone adult (n = 132/204) and another 24% of

two adults together ($n = 49$). The remaining 11.3% was mainly accounted for by 1-2 adults with an immature ($n = 15$) or a black juvenile (BJ) alone ($n = 6$), the most noteworthy being:

1. an immature with greyish underparts, ascending east of Cerro La Olla and joining an adult over the Río Guayapa valley (28 April 2001: 0722h), both heading north and going out of PNEI over Cerro La Cumbre.
2. a BJ with some white on front of ruff and chest (probably residual down feathers) sighted at the Cara Sucia refuse dump south-west of PNEI (20 August 2001: 0700h) with Black Vultures *Coragyps atratus* (F. López, pers. comm.).
3. a BJ, described as having white streaks down the chest (most likely residual down feathers as seen in captive-born young aged 7-9 months), feeding on carrion with 1-2 adults at Los Escobos (11-14 December 2001: 0815h-0910h).

Based on plumage development, the last two young could have been the same. Then on 25 December 2001 (1215h) two adults were sighted at CPG with two young—one black at a distance and the other with much white on the underparts, the latter possibly being the one seen in April but with an additional eight months of white feather growth. All four went north and disappeared over Cerro La Cumbre. The two young may have been siblings. On 2 January 2002 (1208h) three adults were sighted with a BJ over the SE slopes of Cerro León and finally disappeared at Cerro Izcanalar. A year later (26 January 2003: 1058h), three adults were again sighted, and possibly a 4th if the one going down Río Mixtepe was not the one seen *ca.* 14 min later coming from Río Maishtapula (CM/CL) and heading north over Cerro Cola del Caballo. Overall, these observations could indicate the presence of a second family group that is transient only at PNEI. They also point out the difficulty in describing young King Vultures as the black juvenile feathers start emerging through the thick white down of the underparts at fledging and as they are progressively replaced later with white ones on belly, breast and underwing coverts.

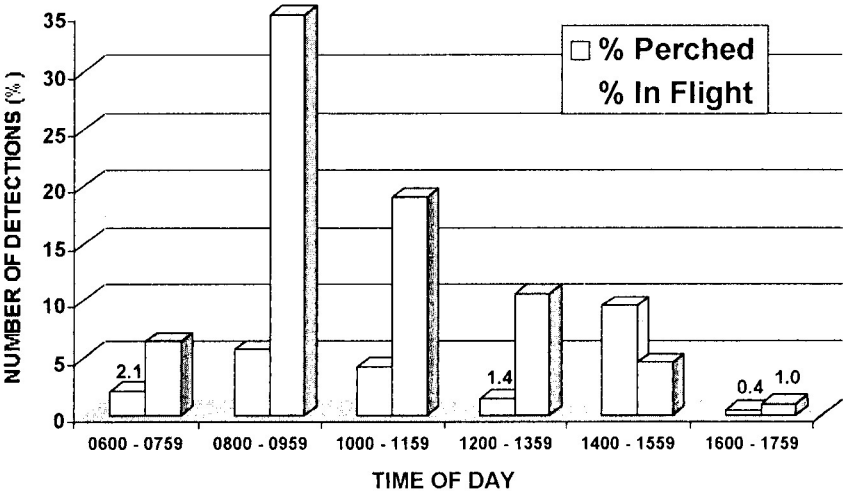
Perch locations

The King Vulture usually perched ($n = 59$ detections) in a dead tree located in a high, prominent position affording a panoramic view, sometimes in a live Guarumo *Cecropia obtusifolia*, Volador *Terminalia oblonga* or Amate *Ficus* sp., and rarely on the ground ($n = 7$). Perch locations (20 March 2001-20 February 2002) are given in Figure 2 and the time of day of the detections, in Figure 3.

More than half (54.5%; $n = 36$) took place near a former or potential nest site. One or two adults were at Jutal ($n = 4$) as early as 0735h or to the north on Huerta Vieja in the afternoon (Figure 3: 1400h-1559h, $n = 24$). We do not know if the birds roosted in the area. The attraction, however, could have been a predator, possibly a felid, circulating in the Jutal forest. The occasional presence of a predator was also indicated when excrement, possibly Puma *Puma concolor* or Ocelot *Leopardus pardalis*, was found much later in the quebrada leading up to the nest as well as a dead neonate White-tailed Deer *Odocoileus virginianus*, showing wounds, on the ridge to the west. The Talnetera and Managuíta forests were also attractive ($n = 8$: 1030h-1220h), especially near a cave at the bottom of a wooded cleft in the Cerro La Leoncita

cliffs where the rangers thought the King Vultures might have nested. The vultures perched there as long as 90 min and sometimes disappeared within the canopy; of course a predator could have been in the area. Some additional detections (13.6%: $n = 9$) involved a food source at Los Escobos (0815h-0825h) or the Cara Sucia refuse dump (not in Figure 2) as well as presumed carrion on Cerro Mixtepe (1030h-1105h) and possibly near a spring west of Río Izcanal (adult on the ground, *ca.* 1530h: B.A. Cruz, pers. comm.).

Figure 3. Number of detections ($n = 283$) in percent of a King Vulture seen on the ground/perched in a tree ($n = 66$) or in flight only ($n = 217$) between 0600h and 1800h from 20 March 2001 to 20 February 2002 at Parque Nacional El Imposible.



The results also showed (18.2%: $n = 12$) that before soaring, the King Vultures sometimes made one or more low-altitude changes in location, each flight followed by a bout of perching. These sightings fall into the time periods 0819h-0830h, 0910h-0930h and 1005h-1035h. Sometimes the vulture was first seen perched ($n = 5$): *e.g.*, at the top of a tree along the east bank of Río Izcanal; at the summit of Cerro Izcanalar, where it took a spread-wing posture, and then flew north to perch near the Río El Venado confluence. At other times it was seen flying to a prominent perch ($n = 5$): *e.g.*, from Río El Venado to the upper elevations of El Pulguero, later returning to the REV canyons; from Los Escobos to the SE slopes of Cerro León; from Cuevona (gallery forests north of CI) or Tamagaz to Cerro Izcanalar or Cerro La Olla. The most noteworthy sighting was of an adult and a black juvenile coming from Tamagaz (22 December 2001: 0819h): the juvenile disappeared along Qda. Agua Prieta east of CLO, but the adult perched in the Caobos forest, then north of the RG/QAP confluence, finally soared and disappeared over the buffer zone east of the upper QAP, presumably leaving PNEI. The King Vultures also occasionally interrupted soaring flight to perch (13.6%: $n = 9$). For example, two adults abruptly descended from the south at 0705h to spend 30 min on the Guacoquera cliffs east of CPG, where they spent time preening, then headed

back out south. Twice an adult was high in a thermal (0900h, 0930h) when it suddenly peeled out, perhaps to more closely monitor something, perching for over 2 hrs near the summit of Cerro El Pulguerón or plunging to the gallery forest near the RG/REV confluence, where it spent 25 min before taking another thermal and disappearing high over Monte Hermoso. Several observations of a lone adult perched along the CL/CPG ridges—south of Cerro León (1240h, 1400h), at CPG (1255h), north of Casco San Benito (1620h)—as well as south of Escobos (1143h) probably also represent birds that were soaring and momentarily perched.

In-flight data

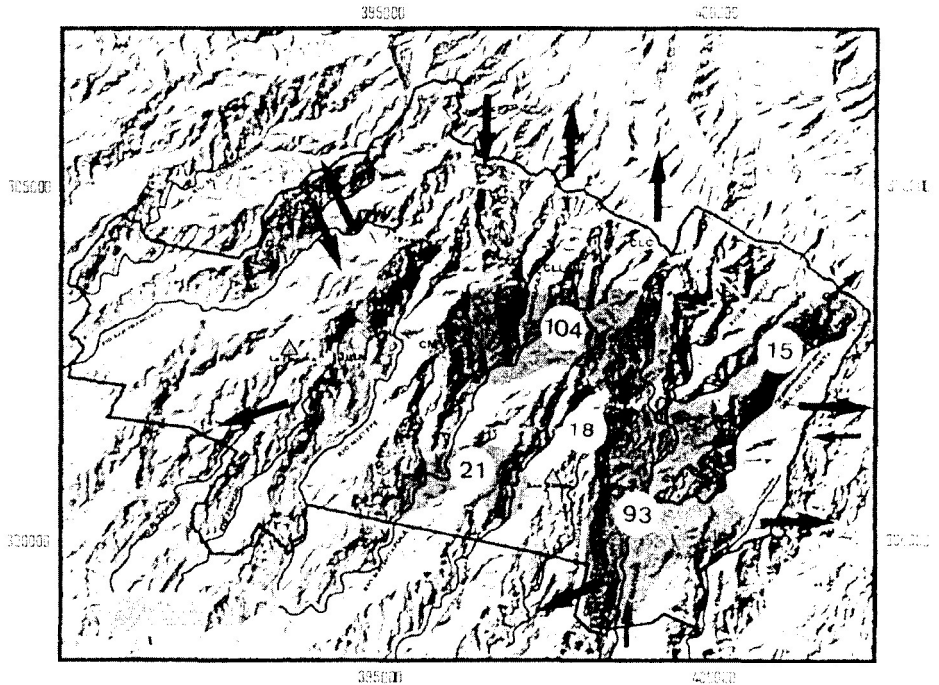
These sightings include only flight sequences in which no bouts of perching were observed. They were most frequently seen (45.6%) between 0800h-0959h (Figure 3: $n = 99/217$ detections), especially from 0900h. When possible, their approximate routes were traced and measured using 1:25,000-scale maps (MOP 1983, 1984). We grouped the data according to the amount of information recorded, which depended on notation methods as well as visibility from the observation points:

1. *Point sightings* ($n = 53$ sightings, 68 detections).—Geographic location and time of day recorded but no flight circuit mapped. Some data correspond to sightings transmitted by radio to VC and MAS (10); others to those reported for the Raptor Monitoring Project in the San Benito Sector (26).
2. *Short, or partial, flight circuits* (SC: $n = 58$ sightings, 71 detections).—Usually direct from one point to another, after which nothing more was recorded or the bird was lost from sight. Showed a mean distance of 1.4km (range: *ca.* 375m to 2.75km).
3. *Long flight circuits* (LC: $n = 49$ sightings, 78 detections).—Took place at much higher altitude than the preceding ones and made extensive use of the wind as well as orographic air flow over the mountains or thermal convection or both; usually following indirect sinuous paths. Sometimes the King Vultures glided to a location to climb on a thermal (14 sightings) and then backtracked (10/14). The LCs that could be measured (30/49) showed a mean of 6.6km (range: 4.4km to 15.5km; the longest made by a BJ in search of its parent(s) which it finally joined). Six more covered only 3.0-3.6km and form an SC-LC transition group.

Thirty-seven percent of King Vulture flight activity within PNEI took place from the eastern slopes of CM through CL to El Pulguero and south to Las Escaleras and the headwaters of Río Izcanal (Figure 4: 104). A second major area of activity (33.1%) extended south (Figure 4: 93) over the Río Guayapa valley to the limits of the buffer zone, east to Tamagaz and north to CLO. The area from the Guacoquera cliffs (east of CPG) through Escobos and the RG/QAP confluence provided good thermal lift as did some areas farther south, particularly La Pinera on the western ridge. Additional activity took place west of Casco San Benito to southern Río Maishtapula (21), at CPG (18), the gateway from the Río Guayapa valley to the Río Izcanal and Río Maishtapula drainages, and along the Pulguerón massif to the east (15). However, King Vultures were also seen along Río Mixtepe (8), over Casco San Benito and Casco La Fincona (4), north of Paso (4) and along the northern

limits from CLC to CCS (6). In four other sightings (25-28 April 2001, 10 February 2002) two adults ascended far to the ESE at 0620h-0720h and 0915h, respectively, which led us to speculate they had found carrion there.

Figure 4. Main areas of King Vulture flight activity at Parque Nacional El Imposible and buffer zones from 20 March 2001 to 20 February 2002. Point sightings (68), short flight circuits (71 starting locations and 71 end locations) and long flight circuits (71 starting locations only) are combined ($n = 281$ detections). The numbers in the white circles represent the number of detections within a given area. Arrows indicate directions of departures or arrivals. For names of cerros, ríos and cascós, see Figure 2.



The LC data show that the King Vultures leave PNEI ($n = 37$ detections), presumably in search of food, and sometimes have been seen entering the park ($n = 5$ detections). 51.4% of the departures were to the north (see Figure 4), 0722h at the earliest, over Cerro La Cumbre (13) or the Maishtapula-Leoncita massifs (6), and once an adult came in from the north over Cerro El Caballo. Strong updrafts over the Río Guayapa/Qda. Agua Prieta confluence sometimes hindered the birds in getting airborne and advancing north, and once (11 February 2002), two adults, after an unsuccessful attempt, spent nearly 1 1/2 hrs fighting the winds—hovering motionless, drifting east or south and back, abruptly dropping down and being pushed back up, hovering again—before finding an air current and gliding out. The King Vultures also went out over Cerro Campana (3); to the NW (3), presumably to Finca Las Mercedes, one returning 10 min later; to the SW over Río El Corozo (1) or over La Pinera (6) toward Río Aguachapío; to the SE (5) over Qda. El Limón, and also returning (2). One adult travelled from west of San Francisco Menéndez to the south and

then east, finally making a steep descent into the Río Guayapa valley near the QAP confluence (18 February 2002: 1012h). Locals at northernmost PNEI have also seen King Vultures come from the west, go east over the Tacuba basin and enter PNEI along the northern limits; and at Cerro Campana the birds have sometimes glided high to the NE and then abruptly turned back. Riding on the winds*i.e.*, making multiple straight paths and abrupt turns at nearly right angles relative to the ground by going upwind, crosswind, downwind, crosswind etc. was also observed on 9 February 2002 (1506h). After numerous manoeuvres in north-eastern PNEI, one adult headed toward the RG/REV confluence and when it met its partner, going east on a close parallel path, each abruptly turned right, one gliding north and the other, south. Perhaps their behaviours were part of an aerial display, as seen in King Vultures elsewhere (Schlee 2001). Finally, five complex LCs were identified as low-altitude foraging, areas being thoroughly searched from 20 min to nearly 2 hrs*e.g.*, the Río Guayapa valley from the southern limits of the buffer zone north to Río El Venado; or the canyons and quebradas of the upper Ríos Maishtapula and Managuïta and east over the Isidro coffee plantation to El Pulguero.

CONCLUSIONS

The only confirmed breedings of the King Vulture in El Salvador are in northern Morazán and at Parque Nacional El Imposible in Ahuachapán. Data from 1976 to 1996 indicate that two pairs were breeding at PNEI but numerical abundance of the species did not increase. Our observations suggest that only one pair currently nests within the park, but sightings of young lead us to believe that a 2nd pair may still be in the area but transient only at PNEI. The 3rd adult sighted occasionally could be the survivor of a former pair or an offspring that has not dispersed. The lower number of King Vultures could be due to diminishing food sources. Cattle are no longer present within the boundaries of the park, and the former pastures as well as the abandoned corn and bean fields are now filled with older secondary growth. In the first stages of succession White-tailed Deer were fairly common, but the species is no longer present in the Río Guayapa valley and rare at La Fincona and on the lomas of Mixtepe, where some poaching has taken place. The decline in the number of King Vultures could also be related to the loss of genetic variability if inbreeding has been excessive, leading to lower reproductive performance or a decreased hatching rate. Almost no data are available on mortality or dispersal patterns of the young. Once the skeleton of a black juvenile was found—some 7 or 8 years ago along Río Maishtapula; thought to have been the victim of human persecution. If mortality has not been a major factor, presumably older young have dispersed, perhaps to the nearby forested areas of Guatemala, to Parque Nacional Montecristo about 90km to the north-east or even as far as Morazán. Are such movements plausible? The heavy wing loading of the King Vulture, calculated at 72.8 Newton/m² (Houston 1988), places it among the vulture species that can fly cross-country for food, sometimes foraging as far as 100km from nest sites, at least in Africa, using thermals as stepping stones or being able to glide as far as 80km without losing altitude if the thermals form a street (Pennycuik 1973). The distance travelled depends on the direction and

velocity of the wind as well as the positioning of thermals. As shown in this study, the King Vultures make extensive use of the winds in and around PNEI as well as thermal convection and orographic airflow over the mountainous terrain.

The conservation of the species in El Salvador should be enhanced by the certification of ecologically-friendly shade-coffee plantations in conjunction with the implementation of the Mesoamerican Biological Corridor and the Salvadoran system of protected areas (SANP), the latter comprising 1.87% of Salvadoran territory (MARN 2003). The certification programme (Rainforest Alliance Certified) was initiated in January 2000 by SalvaNATURA (The Ecological Foundation of El Salvador) under the project "Coffee and Biodiversity" co-ordinated by PROCAFÉ (Fundación Salvadoreña para Investigaciones del Café) and financed by the Global Environment Fund (SalvaNATURA 2002). It is based on such principles as not cutting forest cover, conserving forest fragments, no hunting and minimal use of agrochemicals (SalvaNATURA 2001a). Biodiversity in shade-coffee plantations is, in general, quite similar in composition and magnitude to that in natural forest at the same altitude (Monro 2002), and in some Salvadoran co-operatives enrolled for certification, up to 21 species of medium to large-sized mammals, including deer, have been inventoried (SalvaNATURA 2001b). Shade-coffee plantations are an essential component of the Mesoamerican Biological Corridor, a network of interconnected protected areas running from Selva Maya in southern Mexico to the Darién in Panama and aimed at promoting conservation through sustainable development (see Corrales & Zúñiga 2002) and in El Salvador shade coffee makes up 5/6 of the territory earmarked for this project (Monro 2002). The pilot area for the certification project is the Cordillera Costera de Apaneca-Illamatepec which is also part of a proposed biological corridor comprising the Barra de Santiago, PNEI, Complejo Los Volcanes and the Complejo San Marcelino Wildlife Refuge (see Reyna de Aguilar *et al.* 1996). Data from this study show that the King Vultures go to and from the cordillera east and south-east of PNEI, presumably in search of food. Use of the area for nesting would probably depend on the availability, in the more remote or inaccessible areas, of large-sized tree species capable of producing snags, fallen logs, broken-top trees and cavities, all of which are characteristic of primary or old-growth forest.

The protected areas along with the shade-coffee plantations and buffer zones have been organised into biological corridors (for a map, see MARN 2000b). Of the four that comprise the current programme, the Apaneca corridor cited above and the Montecristo corridor, which comprises San Diego y La Barra, Parque Nacional Montecristo, El Pital and the Pinares de Chalatenango (Reyna de Aguilar *et al.* 1996), along with the newly-created La Fraternidad Biosphere Reserve (MARN 2003) will probably play a fundamental role in the conservation of the King Vulture. The northern biological corridor, although currently under consideration, has not yet officially entered the programme and most of the natural areas within it are not protected (see MARN 2000b). This study shows that the pine-oak forests of northern Morazán are also vital to the survival of the King Vulture in El Salvador.

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