

The conservation status of the Socorro Mockingbird *Mimodes graysoni* in 1993-1994

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Summary

The Socorro Mockingbird *Mimodes graysoni* is endemic to Socorro Island, Mexico, and has declined dramatically in this century. Study of its population size, distribution, and structure is currently under way to help assess its conservation status. In 1993 and 1994 215 Socorro Mockingbirds were ringed; a modified Lincoln index yielded a population estimate of 353 ± 66 individuals in 1994. Most of the birds observed occupied a small region at high elevation that covered less than 10% of the island's area. Average territory size was 1.48 ± 0.71 ha, $n = 11$. Of the 86 birds banded in 1993 67% were adults and 33% subadults. Of the 170 birds detected in 1994, including new captures and ringed individuals from the previous year, 44% were adults and 56% subadults. In 1993 62% were male and 38% female; in 1994 56% were male and 44% were female. The sex ratio of the population was similar to that of other undisturbed Mimid populations, which argues against the possibility that cats might prey disproportionately on incubating females. Moreover, the presence of young birds in both years indicates that successful reproduction was occurring and that the population was not suffering catastrophic nest failure, as might be caused by cat predation on nestlings or fledglings. Northern Mockingbirds *Mimus polyglottos*, which first arrived on Socorro in the 1970s, occupied mainly open areas produced by sheep grazing, which suggests that the Socorro Mockingbird is not being competitively displaced. Our observations indicate that habitat degradation by sheep is the most probable cause of the Socorro Mockingbird's decline.

El Cenzontle de Isla Socorro *Mimodes graysoni* es una especie endémica de esa isla mexicana cuya población ha declinado dramáticamente en este siglo. El estudio del tamaño, distribución y estructura de su población es necesario para determinar la situación de esta especie. Entre 1993 y 1994 anillamos a 215 cenzontles; con un índice de Lincoln modificado estimamos 353 ± 66 individuos en 1994. La mayoría de las aves habitaba una porción montañosa que representa menos del 10% del área de la isla. El tamaño promedio de 11 territorios fue 1.48 ± 0.71 ha. De los 86 cenzontles anillados en 1993, los adultos constituyeron el 67% y los subadultos el 33%. De las 170 aves detectadas en 1994, los adultos constituyeron el 44% y los subadultos el 56%. En 1993 los machos constituyeron el 62% y las hembras el 38%; en 1994 los machos constituyeron el 56% y las hembras el 44%. La proporción de sexos es similar a la de otras poblaciones no perturbadas de Mímidos y la presencia de juveniles sugiere anidación exitosa y ausencia de fracasos de anidación catastróficos, como podría esperarse de la degradación por gatos de hembras incubantes, polluelos, o juveniles. La distribución de los Cenzontles Nortefios *Mimus polyglottos*, principalmente en áreas abiertas producidas por el sobrepastoreo de borregos, sugiere que el Cenzontle de Isla Socorro no ha sido desplazado competitivamente. Nuestras observaciones indican que la degradación del habitat es la causa más probable del declive poblacional del Cenzontle de Isla Socorro.

Introduction

The Revillagigedo Archipelago consists of four volcanic islands in the Mexican Pacific: Socorro, Clarión, San Benedicto and Roca Partida. Isla Socorro has the largest number of plant and animal species as well as the largest number of endemics (Levin and Moran 1989, Brattstrom 1990). On Socorro all the native resident land-birds are endemic to the level of genus, species, or subspecies (Brattstrom 1990). Two species are considered endangered, the Socorro Mockingbird and the Townsend's Shearwater *Puffinus auricularis*. The Socorro Dove *Zenaida graysoni*, is extinct in the wild but survives in captivity. The Socorro Elf Owl *Micrathene whitneyi graysoni* is very likely extinct (Collar *et al.* 1992, Wehtje *et al.* 1993).

The Socorro Mockingbird represents a monotypic genus endemic to Isla Socorro (Brattstrom and Howell 1956). Formerly abundant on Socorro, this species has declined since the middle of this century. Evidence of the decline of the Socorro Mockingbird comes from its shrinking range on the island, as can be inferred from accounts of several biologists since the last century to the present (Townsend 1890, Anthony 1898, McLellan 1926, Brattstrom and Howell 1956, Villa 1960, Jehl and Parkes 1982, 1983). As a consequence of its restricted range and small population size, the Socorro Mockingbird is considered critically endangered (Collar *et al.* 1992). Possible causes of the species's decline include predation from feral cats, habitat destruction caused by feral sheep, and competition with recently arrived Northern Mockingbirds *Mimus polyglottos* (Jehl and Parkes 1982, 1983).

The relative contributions of the three possible causes implicated in the decline of the Socorro Mockingbird have not yet been assessed. Jehl and Parkes (1982, 1983) argued that predation by introduced feral cats was primarily responsible. Wehtje *et al.* (1993) also considered that cats were responsible for the decline. Cats probably arrived after the establishment of the military base in 1957 but their distribution and abundance remain inadequately studied (Veitch 1989). Evidence implicating cats is so far circumstantial: the decline occurred soon after the presumed date of cat release.

In contrast to Wehtje *et al.* (1993), Castellanos and Rodríguez-Estrella (1993) considered sheep-induced habitat alteration to be the main cause of the decline of the endemic mockingbird. Feral sheep have proliferated on Socorro since their release in 1869 (Brattstrom 1990). Their overgrazing has caused accelerated erosion and produced extensive savannas that probably were not present a century ago; the southern fifth of Socorro is now nearly devoid of trees. Socorro Mockingbirds are now absent from the most heavily damaged areas, which span some locations where the endemic birds had been sighted in the past (Jehl and Parkes 1983, Castellanos and Rodríguez-Estrella 1993).

Competitive exclusion is the third plausible cause. Northern Mockingbirds colonized Socorro between 1971 and 1978 (Jehl and Parkes 1983). Their subsequent increase, coincident with the decline in the Socorro Mockingbird, would represent one of the most dramatic cases of ecological replacement known among birds, together with the replacement of the endemic Socorro Dove by the mainland Mourning Dove *Zenaida macroura*. The hypothesis that invading Northern Mockingbirds have competitively displaced Socorro

Mockingbirds is appealing. Nevertheless, Jehl and Parkes (1983) argued that the endemic mockingbirds probably were reduced in number prior to the arrival of their northern counterpart and that competition did not have a direct effect. Similar arguments downplaying a direct role of competition have been advanced for other island "replacements" (Diamond and Veitch 1981).

The first comprehensive estimates of the Socorro Mockingbird population size were made in this decade. Castellanos and Rodríguez-Estrella (1993) estimated 50–60 pairs for the whole island; they made brief visits to Isla Socorro in 1988 and 1990. Wehtje *et al.* (1993) reported an estimated 80–200 pairs for the whole island, based on the same dataset as the preceding work, combined with observations from one more brief visit in August, 1991. These reports have limited utility for several reasons: the algorithms used to obtain the population estimates were not explained; both island-wide population estimates were based on census coverage that excluded large areas of the island; both combined sightings obtained in different years by different authors; and neither was based on counts of marked individuals, so the same birds may have been tallied repeatedly. Another source of error in these population estimates may derive from seasonal differences in distribution and detectability of Socorro Mockingbirds, as suggested by Brattstrom and Howell (1956).

This paper describes an ongoing intensive study of the demography and breeding ecology of the Socorro Mockingbird, the aims of which are (1) to describe the distribution and size of the surviving population; (2) to estimate demographic parameters, such as survival rates, territory fidelity and movements; (3) to determine the role of habitat destruction, predation and competition; and eventually (4) to carry out a population viability analysis. Here we present preliminary data, based on our programme of individual colour-ringing, on estimated population size, distribution, age structure, sex ratios, territory size and site fidelity, leading to an assessment of the conservation status of this species.

Methods

Isla Socorro was visited from 7 to 19 January 1993, and J.E.M.G. conducted further fieldwork during 6 June–5 August 1993 and 18 February–4 June 1994. Socorro has a total area of about 132 km² (our unpubl. figure, estimated from satellite imagery). To assess the present distribution and abundance of the surviving Socorro Mockingbird population different regions of the island were visited systematically; searches were initiated in areas that were previously known to host *Mimodes* and gradually extended to new locations around the island's summit (Mt Evermann) and below. Socorro Mockingbirds were captured with McCamey Potter-type cage traps. During the first year intensive searches were made for territorial males and attempts made to ring all *Mimodes* present in their territories. In the second year the same locations were visited to ensure a constant search effort with searches for singing males and associated birds in low elevation fig groves on the island's northern and western sides. Each individual was ringed, measured, weighed and released according to the protocols outlined by Ralph *et al.* (1993). Each mockingbird was marked with one numbered aluminum ring and two plastic colour rings.

Population size was estimated by means of the modified Lincoln index (Pollock *et al.* 1990):

$$N = [(n_1 + 1)(n_2 + 1)(m_2 + 1)^{-1}] - 1$$

where N is the estimated population size, n_1 is the sample of animals caught and released in the first period, n_2 is the sample of animals captured in the second period, including newly trapped individuals and recaptures, and m_2 is the number of previously marked individuals caught in the second period (the number resighted but not caught is also included here).

The approximate variance is given by:

$$\text{var}N = (n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)(m_2 + 1)^{-2}(m_2 + 2)^{-1}$$

and the approximate 95% confidence interval under the assumption of normality is given by:

$$N \pm 1.96 (\text{var}N)^{0.5}$$

The model assumes that: (1) the population is closed to additions (births or immigrants) and deletions (deaths or emigrants); (2) all animals are equally likely to be captured in each sample; and (3) marks are not lost and are not overlooked by the observer. If additions occur, the estimator is valid for population size at the second period; if deletions occur the estimator is valid for the first period (Pollock *et al.* 1990). To maintain the assumption of equal catchability, Nichols *et al.* (1981) recommended use of a different technique for recapture; methods used in this study addressed this assumption by combining resightings as well as recaptures. Because of minimal loss of colour rings, it was possible in 1994 to identify unambiguously all previously marked birds encountered.

To investigate population age structure, subadults and adults were categorized by inspecting plumage and iris colour: subadults have spotted breasts, greyish irides, and yellowish gape flanges; adults have unspotted breasts, reddish irides, and a dark gape (Martínez-Gómez and Curry 1995). To assess population sex ratio, the sex of banded birds was determined based on vocalizations, behaviour and a linear discriminant function based on wing and tarsal measurements (J. E. Martínez-Gómez and R. L. Curry, unpublished data). Socorro Mockingbird territories were mapped by observing territorial behaviour, such as border disputes between birds or by playing taped conspecific vocalizations to elicit territorial defence. Coordinates of these localities were obtained with a GPS receiver (SONY IPS-760) and plotted on a Cartesian plane, and an estimate made of the area of the convex polygon defined by the outermost points.

To permit preliminary analysis of the three factors implicated in the Socorro Mockingbird's decline, locations of disturbed and undisturbed habitat, Northern Mockingbirds and cat signs were noted on a map of the island based on aerial photographs, using prominent topographic features for reference. (More detailed analysis of spatial patterns using Geographic Information System methods will appear elsewhere.) In coordination with the military personnel, trapping of feral cats was effected by hunting or with Tomahawk traps and analysis made of stomach and scat contents to investigate cat feeding habits.

Table 1. Numbers of Socorro Mockingbirds ringed during the period of study

	Males	Females	Sex ratio	Undetermined
<i>1993: newly ringed birds</i>				
Subadults	12	14	0.86	2
Adults	38	16	2.38	4
<i>1994: newly ringed birds</i>				
Subadults	45	48	0.94	3
Adults	19	10	1.90	4
<i>1994: resightings of birds</i>				
Ringed in 1993				
Ringed as subadults	5	5	1.00	0
Ringed as adults	21	8	2.63	2
<i>1994: totals</i>				
Subadults	45	48	0.94	3
Adults	45	23	1.96	6

Sex ratio values (males : females) shown in boldface are based on all ringed birds present in the specified category in a given year.

Results and discussion

Population structure and size

A total of 215 Socorro Mockingbirds were ringed (Table 1). Age structure shifted towards younger birds in the second year ($\chi^2 = 13.1$, $df = 1$, $P = 0.003$). Of the 86 Socorro Mockingbirds banded in 1993, 58 (67%) were adults and 28 (33%) were subadults. The 170 ringed individuals present in 1994 included 74 (44%) newly ringed or resighted adults and 96 (56%) newly ringed subadults. These proportions may have been influenced by differences in sampling dates in the two years: June–July in 1993, after the breeding season; and during the peak of breeding in 1994. The elevated proportion of subadult birds in 1994 consequently may reflect the increased chance of trapping juveniles before they dispersed from their natal territories.

Little variation in sex ratio was found between years among either subadults or adults but there was evidence of a shift towards males among older birds. The sex of 202 ringed Socorro Mockingbirds was determined (Table 1). It was not possible to sex 13 birds that were moulting at the time of capture and for which behavioural data were lacking. Among subadults, sex ratio was close to unity in both 1993 (46% males) and 1994 (48% males; $\chi^2 = 0.04$, $df = 1$, $P = 0.84$). Among marked adults, the sex ratio also varied little between years, with males predominating in both (70% and 66% males in 1993 and 1994 respectively; $\chi^2 = 0.24$, $df = 1$, $P = 0.62$). Combining data from both years, the proportion of birds that were male was greater among adults (68%) than among subadults (48%; $\chi^2 = 10.0$, $df = 1$, $P = 0.002$).

Results concerning age and sex composition are sufficient to support preliminary conclusions about reproduction in the *Mimodes* population. The presence of young birds indicates that successful reproduction occurred in both years. Therefore, the population did not suffer catastrophic nest failure during the study, as might result when an island bird faces nest predation by an

introduced predator (e.g. *Rattus*, Tomkins 1985, *Boiga* snakes, Savidge 1987) or trampling by sheep of ground nests, as hypothesized for *Mimodes* by Jehl and Parkes (1983) without knowledge of its nesting biology. While the shift in sex ratio with age suggests slightly higher mortality among females (see below), the adult sex ratio remains similar to that of other undisturbed Mimid populations (Breitwisch 1989, Curry 1989, Curry and Grant 1989, 1990). This evidence and the fact that Socorro Mockingbirds have arboreal nests (Martínez-Gómez and Curry 1995) suggest that the population also does not show abnormal patterns of adult mortality, as might result from cats preying directly on incubating females. Nonetheless, these results do not rule out a continued gradual decline in the population as a whole.

The data from this study permit estimation of the total population size. Because the proportion of additions (immatures and juveniles) was large in 1994, the estimate of population size is likely to represent best the number of birds present in that year (Pollock *et al.* 1990). Of the 86 mockingbirds ringed in 1993, we resighted 41 (47.6%) in 1994 (Table 1). Combined with new 1994 captures, the modified Lincoln index yields a total population estimate of 353 ± 66 individuals (95% confidence interval). The percentage of resighted birds ringed as adults was higher (54%) than that of subadults (38%) and the percentage of males that were resighted was higher (52%) than that of females (43%).

This population estimate is similar to the upper end of the range of estimates of Wehtje *et al.* (1993). However, this study's estimate is based on considerably more field observations and the 95% confidence interval is smaller (287–419) than the range of their estimates (160–400). Because sampling was at the peak of breeding in 1994, the estimate of population size was influenced by inclusion of many subadults that may not permanently reside in territories around Mt Evermann (see below). Whether the estimate above accurately represents population size for other times of year will depend on the rates of survival, dispersal and territory establishment of juveniles away from the core set of territories to the periphery of the island.

Distribution

The majority of surviving Socorro Mockingbirds was clustered around the island's summit, at elevations above 600 m (Fig. 1). The group of territories on Mt Evermann covers about 6 km², an area that constitutes less than 10% of the island's surface. However, the distribution of *Mimodes* in this area is not homogeneous. Birds were found principally in moist dwarf forest and in ravines having a mixture of shrubs and trees. Vegetation in occupied areas was dominated by the trees *Ilex socorroensis*, *Guettarda insularis* and *Oreopanax xalapensis* and the understorey species *Triumfetta socorrensis* and *Eupatorium pacificum*. Birds were detected less commonly in taller forest patches. A few birds occurred in groves of fig *Ficus cotinifolia* at low and mid elevations in habitats where sheep damage was moderate or non-existent (i.e. in the northern half of the island). Socorro Mockingbirds were absent from large areas of *Croton masonii* scrub near sea level around the perimeter of the island and from the extensive area of sheep-damaged habitat at low to mid elevation on Socorro's

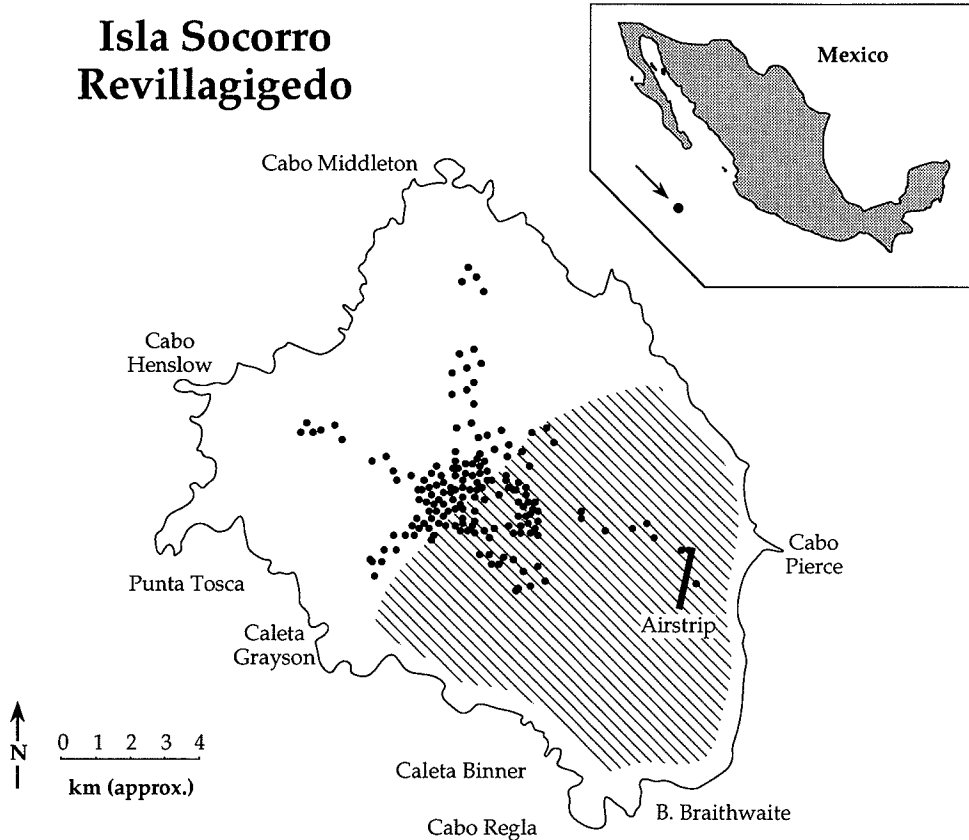


Figure 1. Map of Isla Socorro showing the location of the island and the approximate locations (dots) of Socorro Mockingbirds ringed or sighted in this study, based on searches covering most of the island. Most birds were clustered around the island's summit; those present in the three areas extending to the north, north-east and south-west inhabited forested ravines. 'Vacant' regions in the north are dominated by scrub; in these areas we detected by ear a few other Socorro Mockingbirds in smaller distant ravines. The hatched region indicates areas with greatest habitat alteration caused by sheep; this zone roughly coincides with the distribution of Northern Mockingbirds.

south side that includes damaged *Croton* scrub, pastures of newly arrived grasses, or *Dodonaea viscosa* scrub, which appears to be a product of secondary colonization.

Territory and occupancy

Preliminary information about patterns of territory occupancy indicates a high degree of site fidelity. Territories whose area was measured averaged $1.48 \text{ ha} \pm 0.71 \text{ S.D.}$ ($n = 11$). Of the 41 birds ringed in 1993 and resighted in 1994, 37 (90%) remained near where they were originally captured. The percentage of birds ringed as adults that remained in the same territories (93%; 27 of 29) was slightly greater than that of subadults (80%; 8 of 10) and the percentage of males that remained in the same territories (96%; 25 of 26)

was greater than that of females (77%; 10 of 13). However, the overall high level of territory fidelity (as well as the sex ratio among ringed birds) may be biased because in 1993 emphasis was on ringing and monitoring territorial birds, mainly singing males, to focus on Socorro Mockingbird distribution. More data are required to obtain robust estimates of both survival and territory fidelity.

Predation by cats

Feral introduced cats probably prey on Socorro Mockingbird fledglings, which perch on and near the ground and are incapable of flight for several days after leaving the nest. Because adults often forage on the ground, cats may take them as well. Rodríguez-Estrella *et al.* (1991) argued that predation on birds by cats on Socorro was not very important because only 23% of the 31 cat scats they examined had bird remains, including one with remains of a Socorro Mockingbird (wing feathers; R. Rodríguez-Estrella in litt. 1995). Rodríguez-Estrella *et al.* (1991) based their conclusion in part on data suggesting that cats were most abundant near the coastal naval base, though they also cited evidence that the distribution of cats was expanding. These authors may have underestimated the extent of cat distribution because of their short stays on the island.

We believe that cats currently pose a serious threat to the island avifauna. Cat signs were found at all elevations in the southern part of the island (Fig. 2), which agrees with the earlier assessment of Jehl and Parkes (1982, 1983). The stomach contents of 16 trapped cats were examined and two found to contain Rufous-sided Towhees *Pipilo erythrophthalmus socorroensis*; most remains were of arthropods and of the endemic lizard *Urosaurus auriculatus*. Also examined were 16 groups of cat scats: in 14 (88%) bird remains were found, including Townsend's Shearwaters, Rufous-sided Towhees, Tropical Parulas *Parula pitiayumi graysoni*, and Socorro Wrens *Thryomanes sissonii*. Several Townsend's Shearwater carcasses were discovered on the ground torn apart in a manner that suggests cat predation (c.f. Veitch 1985). Similar evidence of cat predation on shearwaters was found by Jehl and Parkes (1982). However, there was no substantial evidence of cats preying intensively on Socorro Mockingbirds, although two groups of cat scats near the summit contained rectrices possibly from Socorro Mockingbirds.

Habitat destruction

Our observations suggest that the decline of the Socorro Mockingbird was driven, to a large degree, by habitat destruction caused by introduced sheep (Fig. 1). The difference between disturbed and undisturbed habitats is striking. The impact is exemplified in fig forests at low and mid-elevations: in the northern part of the island fig forests have a dense and continuous herbaceous layer and support territories of Socorro Mockingbirds; in contrast, fig forests at similar elevations in the southern part of the island, where the native mockingbird is no longer present, are devoid of the herbaceous layer. The most severely overgrazed areas, covering at least 20% of the island, no longer provide the relatively unbroken shrubby ground cover and moderately dense trees that

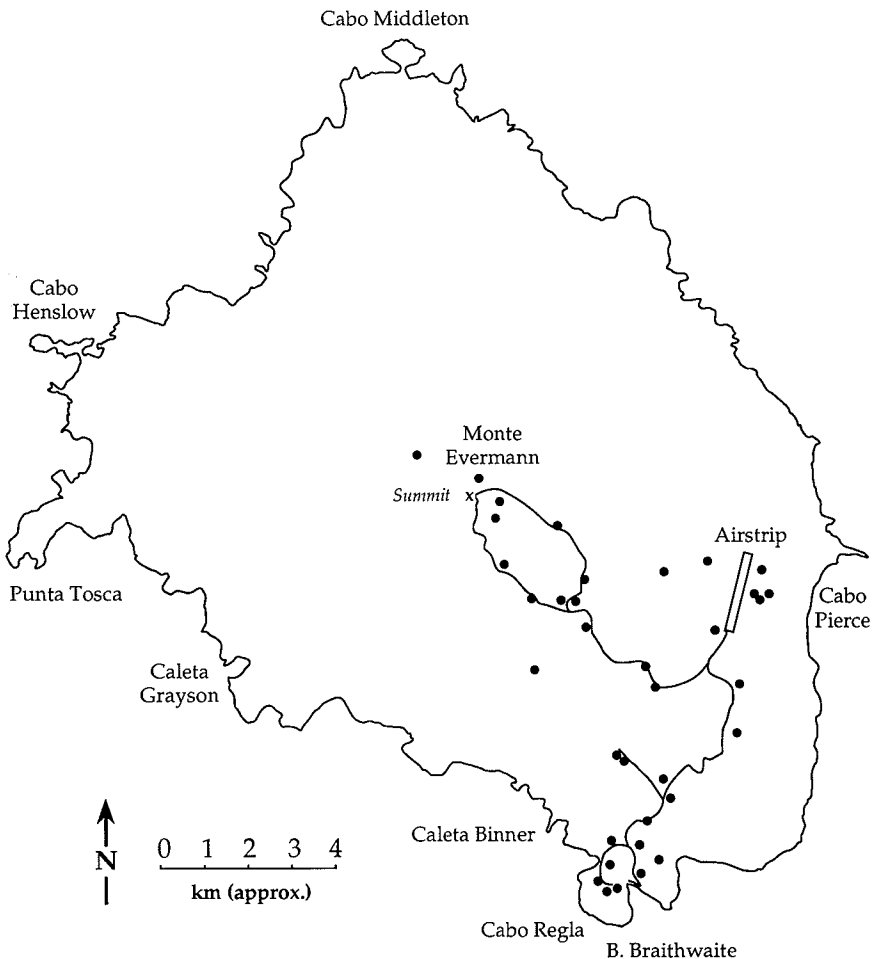


Figure 2. Approximate locations of cat signs (scats, tracks, prey remains, captures) on Isla Socorro. Solid lines depict the island's main road, from the naval base at Cabo Regla to the airstrip, and trails. The distribution of signs overlaps areas where we detected cats by sight or sound; we neither observed cats nor found their signs in the northern part of the island.

Socorro Mockingbirds appear to prefer for nesting (Martínez-Gómez and Curry 1995) or foraging (pers. obs.).

Competition with Northern Mockingbirds

The idea that Socorro Mockingbirds are being competitively displaced derives from the assumption that morphologically similar species occupy similar niches and that, as a consequence, one species may be displaced or eradicated. However, the endemic Socorro Mockingbird is considerably larger than the immigrant Northern Mockingbird and the native bird forages in more heavily vegetated areas (pers. obs.). Furthermore, the range of Northern Mockingbirds is coincident with that of altered habitats on the island (Fig. 1) and Northern

Mockingbirds have their greatest abundance in open areas near the naval base and airstrip that probably were not present before human colonization. These distribution patterns are more parsimoniously explained by differences in habitat preference of the two species rather than competition. Therefore, we concur with Jehl and Parkes (1983) that Northern Mockingbirds probably colonized the island after habitats were significantly altered and were not primarily involved in the decline of the Socorro Mockingbird.

Nonetheless, interference competition could be involved if Northern Mockingbirds were able to displace territorial Socorro Mockingbirds. We found evidence opposing this possibility. On several occasions, we saw Socorro Mockingbirds drive Northern Mockingbirds away from the former's territories. Also, we did not locate any established Northern Mockingbird territories in the northern part of the island where sheep have not yet penetrated. This suggests that Northern Mockingbirds are unable to outcompete Socorro Mockingbirds in undisturbed habitat. This pattern may parallel that of the Bahamas and the West Indies, where range expansion by the small-bodied Northern Mockingbird since the end of last century was probably made possible by anthropogenic alteration of habitats, which in the Bahamas occurred at the expense of the larger Bahama Mockingbird *Mimus gundlachii* (Aldridge 1984, Buden 1988, R.L.C. pers. obs.).

Conservation measures taken

The former Secretaría de Agricultura y Fomento (1934) declared that Socorro island would not be colonized. This policy was modified by the president of Mexico, Adolfo Ruíz Cortines, and the minister of the Navy, Roberto Gómez Maqueo, who approved colonization of the archipelago in 1956 (Velasco-Murgía 1982). The colonization of Socorro by navy personnel took place on 13 January 1957. The first commandant, Donaciano Hernández Carbajal, received several directives from the naval command in Mexico City. One explicitly proscribed killing of the island's land animals (Velasco-Murgía 1982). Since that date the Mexican government has kept navy personnel on Socorro and, since 1977, on Clarión (Brattstrom 1990). Officers were allowed to bring their families to Socorro until 1993. At present only military personnel permanently inhabit the archipelago; no civilians have been authorized to settle any of the islands. Despite the early directive, evidence of human predation on native animals exists. During an expedition organized by the state government of Colima from 18 to 23 March 1972, visitors killed several Socorro Doves for no apparent reason (Velasco-Murgía 1982); this account appears to be the last report of the endemic dove in the wild.

The Secretaría de Desarrollo Social (1994) recently declared the four islands a Biosphere Reserve. A management plan is supposed to be presented within a year of this decree. Although Socorro and Clarión both have introduced predators and grazers, efforts to control cat and sheep populations have been initiated only on Socorro. Unfortunately the control programmes on Socorro are restricted to a limited area of the island and, in the case of sheep, only old males are hunted.

Conservation measures proposed

We concur with Santaella and Sada (1991), Castellanos and Rodríguez-Estrella (1993) and Wehtje *et al.* (1993) and urge immediate implementation of a programme to eradicate sheep and cat populations on Socorro. These actions may be required in order to avert the eventual extinction of the Socorro Mockingbird and other native species, such as Townsend's Shearwater, considered at risk (Collar *et al.* 1992). The most effective course of action probably would be to attempt to eradicate the cats first; removing the sheep might permit regrowth of the vegetation and change the food supply, making subsequent removal of cats more difficult (Veitch 1989).

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