

ERADICATION OF BLACK RATS FROM FARALLÓN DE SAN IGNACIO AND SAN PEDRO MÁRTIR ISLANDS, GULF OF CALIFORNIA, MEXICO

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Abstract—In the Gulf of California, Mexico, several islands have been severely impacted by introduced rats (*Rattus* spp.). A rat eradication project for Farallón de San Ignacio and San Pedro Mártir islands, both globally important seabird colonies, unfolded from planning and baseline studies in 2005 to implementation in 2007. Rats were eradicated via aerial helicopter broadcast of bait, the only method used to date to eradicate rats from large and topographically complex islands. A special aerial bucket developed in New Zealand (Helicopters Otago) was used for the helicopter dispersion of CI-25, a special formulation of Brodifacoum in the form of pellets, provided by Bell Labs. Eradication occurred in September 2007 on Farallón de San Ignacio and in October–November 2007 on San Pedro Mártir. Initial post-eradication monitoring resulted in no sign of rats. There were no losses of native fauna at a population level. Post-eradication monitoring will continue throughout 2008–2009 to confirm both rat absence and ecosystem recovery. Interinstitutional cooperation was essential in achieving complex permitting, logistics, and financial challenges. This project represents the first project of aerial broadcast rat eradication in Latin America.

INTRODUCTION

Introduced vertebrates are known to be a major cause of extinctions and other dramatic changes on islands (Mack et al. 2000; Blackburn et al. 2004; Reaser et al. 2007). In particular, the impact of rats (*Rattus* spp.) on native island plants, invertebrates, and vertebrates has been well documented (Whitaker 1973; Campbell 1991; Cree et al. 1992; Navarrete and Castilla 1993; Lee and Yoo 2002; Towns et al. 2006). Rats are present on about 85% of the world's island chains (Atkinson 1985) and have caused 40%–60% of all bird and reptile extinctions since 1600 (Groombridge 1992).

Two islands that have been impacted by rat introductions are Farallón de San Ignacio (FSI) and San Pedro Mártir (SPM) islands in the Gulf of California, México (Fig. 1). Both islands support seabird colonies of national and international importance (Tershy and Breese 1997; González

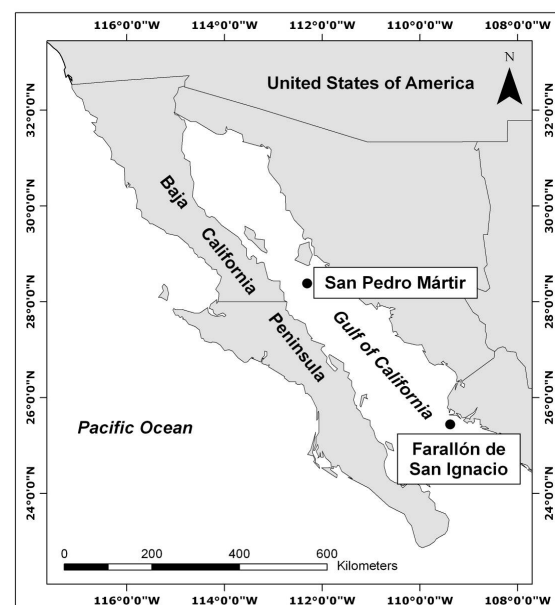


Figure 1. Locations of Farallón de San Ignacio and San Pedro Mártir islands, México.

Bernal et al. 2002), are part of a World Heritage Site (UNESCO), and are legally protected by Mexican law as Natural Protected Areas. Black rats (*Rattus rattus*) are thought to have been accidentally introduced to both islands during guano mining activity in the early 1900s (Tershy et al. 1997). Precise information about local impacts of introduced rats on these islands is scarce (Velarde and Anderson 1994). However, rats are known to have impacted island populations through predation on seabird eggs and chicks on both islands, and fruits and flowers of the cardón (giant cactus; *Pachycereus pringlei*) on SPM (Tershy et al. 1997; A. Samaniego, personal observation). Additionally, the absence of nocturnal seabirds despite suitable habitat on both islands, limited distribution of fishing bats (*Myotis vivesi*) on SPM, and extremely low abundance of the gecko (*Phyllodactylus homolepidurus*) on FSI, are all considered probable consequences of rat predation (Tershy et al. 1997; González Bernal et al. 2002; Frick and Heady 2007; Peralta-García et al. 2007).

To promote the natural restoration of FSI and SPM islands, a rat eradication plan was developed in 2005. The project was headed by the Mexican private organization Grupo de Ecología y Conservación de Islas (GECI), in collaboration with Mexican government agencies SEMAR, SEGOB, CONANP, and SEMARNAT. GECI's sister organizations in the United States (Island Conservation) and Canada (IC Canada), as well as Prescott College in Bahía Kino, were the main collaborators in fundraising, planning, and local support, respectively. Prior to 2006, four rat eradications had been attempted on Mexican islands by putting out stations containing poison baits (Tershy et al. 2002). Three of these eradications (Rasa, San Jorge, and San Roque islands) were successful (Tershy et al. 2002), and one of them (Isabel Island) failed (Rodríguez et al. 2006). All three islands with successful eradications were less than 50 ha in area, whereas Isabel Island was 82 ha, suggesting that the bait station technique may not effectively eradicate rats on larger islands where not all rats can access the bait stations. Because FSI and SPM islands are topographically complex and SPM is large (267 ha), we opted to use a helicopter to disperse rodenticide broadly across each island. Although used effectively elsewhere (Howald et al. 2007), this was the first time that this aerial

procedure was applied in Latin America. The rat eradication project therefore included a 2-year pre-eradication phase in which we acquired baseline population data on rats, and conducted studies to test whether rodenticide pellets were likely to be consumed by native vertebrates. Here we present the results of these preliminary studies, describe the aerial application of rodenticide to each island, and report initial results of post-application monitoring.

METHODS

Site Description

Farallón de San Ignacio (25° 26' 11.5" N, 109° 22' 45.5" W) is a small island (17 ha) located 27 km off the coast of Sinaloa state, México (Fig. 1). It is a tall rock with vertical walls and a flat top at 137 m.a.s.l. (Fig. 2a). Vegetation is completely non-existent. The island is an important seabird nesting site. Blue-footed booby (*Sula nebouxii*), brown booby (*S. leucogaster brewsteri*), red-billed tropicbird (*Phaeton aethereus*), and Heermann's

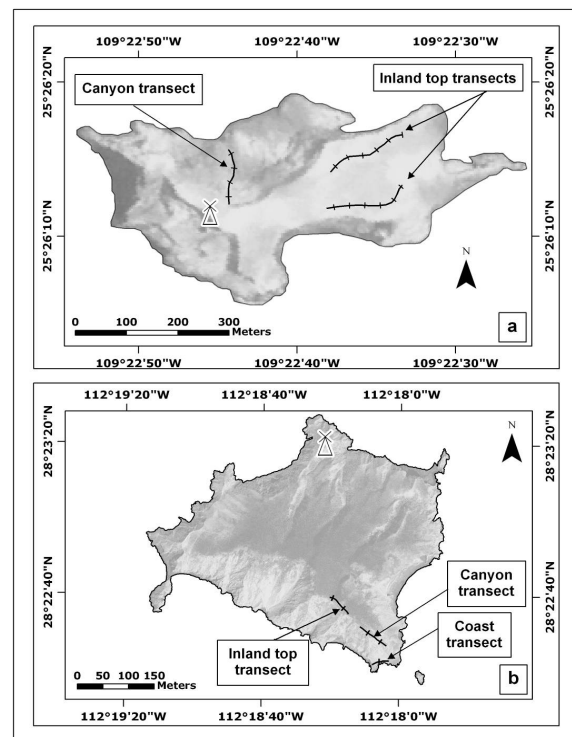


Figure 2. Permanent trapping transects on (a) Farallón de San Ignacio and (b) San Pedro Mártir islands.

gull (*Larus heermanni*) are the most abundant species (González-Bernal et al. 2002). Besides seabirds, the other native vertebrates are three species of lizards (*Aspidoscelis tigris*, *Urosaurus ornatus*, and *Phyllodactylus homolepidurus*; González Bernal et al. 2001a; González Bernal et al. 2001b; Peralta-García et al. 2007) and the California sea lion (*Zalophus californianus*). No native terrestrial mammals occur on the island (CONANP 2000; Case et al. 2002). The only introduced mammal was the black rat *R. rattus* (González-Bernal et al. 2002).

Located 60 km off the coast of Sonora state, México, San Pedro Mártir (28° 23' 0.0" N, 112° 18' 30.0" W) is the most isolated island in the Gulf of California (Fig. 1). The island is 267 ha with a maximum altitude of 305 m.a.s.l., and is dominated by mountainous cliffs (Fig. 2b). It hosts 27 species of plants (cardón forest being the predominant vegetation), 53 of terrestrial birds, 36 of seabirds (8 nesting), 4 of reptiles, and 1 of pinnipeds (Tershy and Breese 1997; Grismer 2002; CONANP 2007). SPM supports some of the biggest populations in the world of blue-footed boobies (*S. nebouxii*), brown boobies (*S. leucogaster brewsteri*), and red-billed tropicbirds (*P. aethereus*). No native terrestrial mammals occur on the island (Case et al. 2002; CONANP 2007). The only introduced mammal was the black rat *R. rattus* (CONANP 2007).

Pre-Eradication Rat Monitoring

To collect baseline data on rat populations prior to application of rodenticide, we established three permanent transects on each of the two islands in May 2005. On SPM the three transects represented the three main habitat types: coast, canyon and inland top (Fig. 2b). Because it was logistically unfeasible to trap along the coast on FSI, we established two transects on the inland top and one transect along a steep canyon (Fig. 2a). Each transect included 15 trapping points at intervals of 20 m. At each point we set 3 devices separated by 2 m: one Tomahawk trap (Tomahawk Live Trap Co, Tomahawk, WI), one Sherman trap (H.B. Sherman trap, Tallahassee, FL), and one indicator block (peanut-flavored wax chew block). Especially for islands without native rodents, indicator blocks are a very useful, inexpensive and practical tool for detecting rodent presence. Traps and blocks were set and checked for three consecutive days at each

trapping session. All traps were opened before sunset, baited with a mix of oats and peanut butter, and checked in the morning. Indicator blocks were set the first afternoon, checked every morning and replaced if they showed any mark. Data recorded included island, date, transect, trapping point, trap type, species captured, and marks on the block (none, rodent bites, and other marks).

Systematic trapping combined with indicator blocks was conducted every three months on both islands from fall 2005 to summer 2007, except fall 2006 for FSI and winter 2006 for both islands. This resulted in one trapping period in fall (2005), one in winter (2005), two in spring (2006, 2007), and two in summer (2006, 2007) on FSI; and two trapping periods in fall (2005, 2006), one in winter (2005), two in spring (2006, 2007), and two in summer (2006, 2007) on SPM. On FSI total capture effort represented 1319 trap-nights and 475 block-nights. On SPM total capture effort represented 1513 trap-nights and 435 block-nights. Percent capture success for each trapping period was calculated according to the number of individuals captured per trap-nights (Tomahawk and Sherman traps combined) given habitat type and trapping date. All captured individuals (100% *R. rattus*) were humanely sacrificed with the anesthetic Pentobarbital sodium (Aranda Labs, Querétaro, México).

Choice of Rodenticide and Potential Impacts on Native Fauna

Bait used was the rodenticide CI-25, developed by Bell Labs (Madison, WI) especially for ecological restoration projects, and proven successful on Anacapa Island in the Channel Islands in 2001 and 2002 (Howald et al. 2005). CI-25 are green, unwaxed, compressed grain, 2 gm pellets containing 25 ppm brodifacoum, which is a second generation anticoagulant. Prior to rat eradication and in order to assess if CI-25 pellets were attractive to island fauna, we conducted palatability experiments of placebo bait on reptiles, seabirds, and fishes (Table 1) on April 3–7, 2006 on FSI and on April 11–16, 2006 on SPM. Placebo bait was also manufactured by Bell Labs and had the same characteristic of the toxic bait except for the rodenticide brodifacoum.

We tested all reptile species whose diet could include grain-type components, and excluded

Table 1 . Species, methods, and reaction of vertebrates exposed to placebo bait pellets of CI-25 (brodifacoum) on Farallón de San Ignacio (FSI) and San Pedro Mártir (SPM) islands.

Species	Family	Island	Method of exposure	Reaction
Fishes				
<i>Prionurus punctatus</i>	Acanthuridae	FSI	Natural conditions	No consumption
<i>Balistes polylepis</i>	Balistidae	SPM	Natural conditions	No consumption
<i>Ophioblennius steindachneri</i>	Blenniidae	FSI, SPM	Natural conditions	Inspection, no consumption
<i>Cirrhitus rivulatus</i>	Cirrhitidae	FSI	Natural conditions	No consumption
<i>Diodon holocanthus</i>	Diodontidae	FSI	Natural conditions	No consumption
<i>Haemulon sexfasciatum</i>	Haemulidae	FSI, SPM	Natural conditions	No consumption
<i>Girella simplicidens</i>	Kiphosidae	SPM	Natural conditions	No consumption
<i>Bodianus diplotaenia</i>	Labridae	SPM	Natural conditions	No consumption
<i>Semicossyphus pulcher</i>	Labridae	SPM	Natural conditions	No consumption
<i>Thalassoma lucasanum</i>	Labridae	FSI, SPM	Natural conditions	No consumption
<i>Lutjanus argentiventris</i>	Lutjanidae	SPM	Natural conditions	No consumption
<i>Lutjanus novemfasciatus</i>	Lutjanidae	SPM	Natural conditions	No consumption
<i>Holacanthus passer</i>	Pomacanthidae	FSI, SPM	Natural conditions	No consumption
<i>Microspathodon dorsalis</i>	Pomacanthidae	SPM	Natural conditions	No consumption
<i>Stegastes acapulcoensis</i>	Pomacentridae	FSI	Natural conditions	No consumption
<i>Stegastes flavilatus</i>	Pomacentridae	FSI	Natural conditions	No consumption
<i>Abudefduf troschelii</i>	Pomacentridae	FSI, SPM	Natural conditions	No consumption
<i>Chromis atrilobata</i>	Pomacentridae	FSI, SPM	Natural conditions	No consumption
<i>Cephalopholis panamensis</i>	Serranidae	SPM	Natural conditions	No consumption
<i>Epinephelus labriformis</i>	Serranidae	FSI	Natural conditions	No consumption
<i>Mycteroperca rosacea</i>	Serranidae	SPM	Natural conditions	No consumption
<i>Paranthias colonus</i>	Serranidae	FSI, SPM	Natural conditions	No consumption
<i>Axoclinus carminalis</i>	Tripterygiidae	SPM	Natural conditions	No consumption
Reptiles				
<i>Urosaurus ornatus</i>	Phrynosomatidae	FSI	Natural conditions	Inspection, no consumption
<i>Uta palmeri</i>	Phrynosomatidae	SPM	Natural conditions and captivity	Inspection, no consumption
<i>Aspidoscelis tigris</i>	Teiidae	FSI	Natural conditions and captivity	Inspection, no consumption
<i>Aspidoscelis martyris</i>	Teiidae	SPM	Natural conditions	Inspection, no consumption

Table 1 (continued). Species, methods, and reaction of vertebrates exposed to placebo bait pellets of CI-25 (brodifacoum) on Farallón de San Ignacio (FSI) and San Pedro Mártir (SPM) islands.

Species	Family	Island	Method of exposure	Reaction
Birds				
<i>Larus heermanni</i>	Laridae	FSI, SPM	Natural conditions	No consumption
<i>Sula leucogaster brewsteri</i>	Sulidae	FSI, SPM	Natural conditions	No consumption
<i>Sula nebouxii</i>	Sulidae	FSI, SPM	Natural conditions	No consumption

species with strictly carnivorous diets (e.g., *Phyllodactylus homolepidurus*, *Lampropeltis getula nigrilus*, and *Crotalus atrox*). Twenty adult lizards (10 *Aspidoscelis tigris* on FSI and 10 *Uta palmeri* on SPM) were individually kept in captivity for 5 days in wired cages (90 x 45 x 45 cm) on their respective island. Each individual was offered a 2.0 gm pellet, which was subsequently weighed and checked for bite signs every 24 hrs. Along with the experiment, we made *in situ* observations on adult and juvenile individuals of four species of lizards (*A. tigris* and *Urosaurus ornatus* on FSI; *Uta palmeri* and *A. martyris* on SPM). Between 10:00 and 11:00 a.m., we spread out 10 pieces of placebo bait inside plots of approximately 10 m² in different microhabitats (shoreline, canyon, inland top). In each trial ($n = 15$ per island), we observed the reaction of each species for 15–30 minutes. Reactions to pellets were categorized as a) no consumption (pellets ignored), b) inspection but not consumption, or c) consumption.

For birds we conducted *in situ* observations in order to include the most species possible. Because terrestrial birds are present at very low abundance, they were never present during our observations. Despite the fact that most of the nesting seabirds are piscivorous, we were interested in the reaction of ground nesting seabirds to bait pellets. Observations were conducted during morning hours on areas with abundant individuals (> 50) for five consecutive days on each island. In each trial ($n = 15$ per island), we placed 10 pieces of placebo inside plots of approximately 50 m². Reaction of each species was recorded during 30–60 minutes. Reactions to pellets were categorized as a) no consumption (pellets ignored), b) inspection but not consumption, or c) consumption.

Since the probability of spreading bait beyond 10 m offshore of the islands was minimal, we focused our fish observations on waters immediately adjacent to the islands. Seven underwater observation sessions were conducted (four on FSI and three on SPM). Each session took place in a different day, during the afternoon, and lasted for an hour. At each session one person with free diving equipment remained 3–5 m from shore and made observations along the water column up to 15 m deep. In each event, 10 pieces of placebo were thrown to the ocean. Species present and reaction to pellets were recorded. Reactions were categorized as a) no consumption (pellets ignored), b) inspection but not consumption, or c) consumption.

Bait Application

Because of the size, steepness, and ruggedness of FSI and SPM islands, the most feasible option for achieving eradication was to disperse bait pellets using an aerial drop technique, developed in New Zealand (Towns and Broome 2003) and used previously in several countries (Howald et al. 2007). The bait was broadcast from a helicopter using a stainless steel spreader bucket built in New Zealand (Helicopters Otago, Mosgiel, New Zealand). The helicopter (Bell 206 from Aspen Helicopters, Oxnard, CA) was equipped with a differential GPS to obtain geographic data with high accuracy. A GIS was built to confirm that distribution and application rate within each topographic category area were correct according to planning. On both islands bait was applied to 100% of the island surface. Cliff and canyon areas were treated twice during each drop to allow for the increased planar area that had to be covered. When applying bait to the cliffs, a lateral deflector was adapted on the bucket to narrow the angle of bait dispersion and

minimize the amount of bait spread into the ocean. Because the intertidal zone represents prime habitat for rats, a detailed hand broadcast was conducted by small boat (along shoreline) and by helicopter (above islets) the next day after each aerial drop to ensure adequate bait application. To track the aerial work and map rodenticide densities in the ground, we used a 60 cm per pixel resolution Quickbird satellite image (© 2006 Digital Globe Inc.) of SPM, and an aerial photo of FSI.

Climate and reproductive cycles of both introduced and native species are the main factors to be taken into account for timing rat eradications (Howald et al. 2005). In this case, timing of bait application was determined by weather (dry season), seabird and sea lion activity (non-reproductive season), and rat population activity (low breeding rate). The eradication operation on FSI was carried out on September 27, 2007, with the helicopter operating out of the Mexican Navy base in Topolobampo, Sinaloa, 29 km from the island. A total of 567.5 kg of bait was broadcast by helicopter using a single aerial bait drop and 90 kg of bait was broadcast by hand along shoreline and islets. On average, bait was applied at a rate of 24.4 kg/ha (Fig. 3a). The operation on SPM included two bait drops. The operation base for the first drop was the Mexican Navy MV Sonora (PO152), an oceanic patrol vessel from the Mexican Navy provided for the project that anchored in front of the island. The drop occurred on October 31, 2007. The second drop was based on the island and occurred nine days later on November 9, 2007, with logistics support from the MV Guadalupe, also from the Mexican Navy. Average bait density broadcast was 17.6 kg/ha (Fig. 3b). A total of 5,902.5 kg of bait was broadcast by helicopter and 440 kg by hand along shoreline and islets.

Underwater monitoring was conducted 24 hours after each aerial broadcast, in both the intertidal and sublittoral zones of the two islands. The dive focused primarily in assessing the invertebrate and fish communities, as well as the sea lion colonies. Underwater photographs were taken.

Confirmation Monitoring

The first eradication confirmation monitoring on FSI was carried out seven weeks after the drop, on November 14–17, 2007. 105 Tomahawk traps and 260 indicator blocks were set along permanent

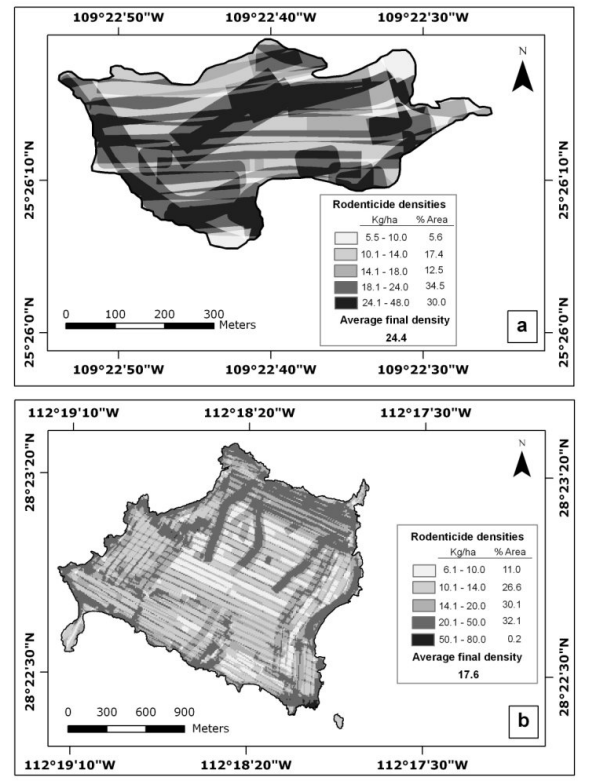


Figure 3. Bait density after (a) a single broadcast on Farallón de San Ignacio Island and (b) a double broadcast on San Pedro Mártir Island, in fall 2007.

transects and around areas with known high rat activity, for three consecutive nights. Capture effort represented 315 trap-nights and 780 block-nights. All accessible areas were walked searching for carcasses (of rats or native species) and signs of rats.

On SPM, it was not possible to return weeks after the drop due to financial and logistic limitations. Therefore, the initial confirmation was based on monitoring of radio-collared rats. Twelve adult females (average weight = 156.2 gm \pm 30.3) and 13 adult males (average weight = 178.2 gm \pm 36.5) were captured in different habitat types and radio-collared 12 days before the first drop. All were released at the capture spot and monitored every night. Based on telemetry indications, 24 individuals were active the day of the first drop. One collar may have become damaged because the signal was lost days before the drop. After the drop, individuals inactive for 2–3 days were assumed to be dead and were subsequently recovered from underground burrows. Date of death was estimated based on carcass condition. All recovered individuals were dissected to confirm cause of

death. Nine days after the first drop, we walked five 500 m transects spread over island, looking for carcasses (of rats or native species) and signs of rats. Thirty-two circular monitoring plots of 3 m radius (28.27 m^2), chosen randomly around the island before the drops, were searched in greater detail to maximize the probability of finding small animals.

RESULTS

Rat Monitoring

Prior to the application of rodenticide, capture success varied between islands, seasons, and habitat types (Fig. 4). On FSI, 238 individuals of *R. rattus* were caught from a total capture effort of 1319 trap-nights (18.0% capture success). The highest mean seasonal capture rate was in summer ($\bar{x} = 29.8\%$; Fig. 4a), and the highest mean capture rate among habitat types was in inland top ($\bar{x} = 18.1\%$; Fig. 4a). 38.1% of all indicator blocks were chewed by rats. On SPM, 252 individuals of *R. rattus* were caught from a total capture effort of 1513 trap-nights (16.7% capture success). The highest seasonal mean capture rate was in summer ($\bar{x} = 32.1\%$; Fig. 4b). Of the habitat types, the highest mean capture rate was in canyon ($\bar{x} = 25.1\%$; Fig. 4b). Rats chewed 21.1% of all indicator blocks.

On FSI, preliminary trapping following application of bait yielded no captures of rats, and there was no evidence of rat chewing on indicator blocks. No rat carcasses were found during searching walks. On SPM, 19 of 24 radio-collared rats were recovered dead, along with one dropped collar. Of the remaining four collared rats, three were located in inaccessible locations (vertical cliffs and under massive rocks); and one, including the active collar, was devoured by a rattlesnake. All recovered rats died underground between 3 and 7 days after the first drop. Dissection of 21 individuals (19 collared plus 2 non-collared found while digging for the first ones) confirmed poisoning as the cause of death in 100% of the rats. Furthermore, stomach content in most individuals was 90% bait. During searching walks and inspections of verification plots, we found two fresh rat carcasses.

Impacts on Native Fauna

Table 1 shows a summary of palatability experiments. None of the reptiles in captivity

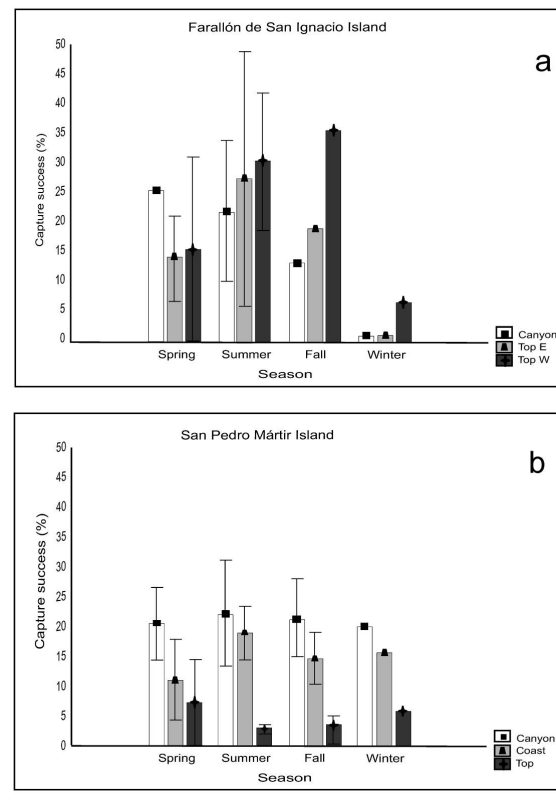


Figure 4. Percentage of capture success of pre-eradication rat trapping per habitat type, on (a) Farallón de San Ignacio Island and (b) San Pedro Mártir Island, from 2005–2007. Heights of bars indicate means, and error bars indicate maximum and minimum values.

consumed bait; all pellets weighed the same at the end of the experiment as at the beginning, and none showed bites. As for the *in situ* observations, the only reaction recorded for all species and islands was “inspection but not consumption.” Seabird species present during the observations were *S. neboxii*, *S. leucogaster brewsteri*, and *Larus heermanni*. The only reaction recorded for all species and islands was “not consumption.” On FSI 13 fish species of 9 families (Table 1) were recorded during the observations, whereas on SPM 17 species of 10 families (Table 1) were recorded. Of a total of 23 fish species observed, 22 did not consume pellets. For the last species (*Ophioblennius steindachneri*), one individual out of a dozen observed ate one piece, but spit it out. The same species was observed on SPM, but was not observed to consume bait pellets.

Twenty-four hours following application of rodenticide, underwater monitoring at both islands

found no traces of pellets on either the sea floor or in tide pools. Five species of invertebrates: red rock crabs (*Grapsus grapsus*), barnacles (*Balanus spp.*), sea urchins (*Echinometra vanbrunti*), and sea stars (*Pharia pyramidata* and *Phataria unifascialis*); 13 fish species of 9 families (Table 1), and sea lions (*Z. californianus*), were recorded in normal conditions in terms of behavior and external aspect.

Seven weeks after the drop, advanced degradation of leftover bait was evident. On the inland's top of FSI, 11 small terrestrial birds (8 *Passer domesticus*, 2 *Columbina passerine*, and 1 *Carpodacus mexicanus*) were found dead, possibly by rodenticide ingestion. Carcasses were too dry to dissect and confirm cause of death. Blue-footed boobies, brown boobies, and red-billed tropicbirds had laid the first eggs of the season and all were intact, without rat chews. During searching walks and inspections of verification plots on SPM, we found seven fresh bird carcasses: six yellow-footed gulls (*Larus livens*) and one common raven (*Corvus corax*), which may have died from poisoning. All lizards, snakes, and other birds observed during the searching walks looked in normal condition in terms of behavior and external aspect.

DISCUSSION AND CONCLUSIONS

Two years of planning, testing, and monitoring were necessary to obtain the basic information for development of a detailed strategy for eradicating rats on FSI and SPM islands, and to comply with complex permitting requirements. Baseline data acquired from pre-eradication monitoring facilitates the confirmation of both eradications, as well as the planning of other eradication and conservation actions in the region. As expected, rats on SPM died between days three to seven after the first bait drop. Initial results indicate that the rat eradications on both FSI and SPM islands were successful.

We believe that application of the rodenticide CI-25 to FSI and SPM islands resulted in minimal adverse effects to island fauna. Results of palatability experiments with the abundant native species suggest that bait pellets intended for rats are not likely to be attractive to many native fish, reptiles, or seabirds. Of the 29 vertebrate species exposed to the placebo bait, 96.5% were not interested in it, and the few that were attracted (three

reptiles, one fish) did not consume even one pellet. Nevertheless, because of their migratory habits, behavior, and potential susceptibility, birds need special attention and more studies. Overall, the loss of native fauna after the broadcast was insignificant at a population level. However, some mortalities were observed during monitoring that may have resulted from rodenticide poisoning: 11 terrestrial birds (3 species of passeriforms) on FSI as well as 7 seabirds (6 yellow-footed gulls and 1 common raven) were found dead. None of these species are abundant on the islands and were not present during our palatability tests. Since these passeriform species are granivorous, and seagulls and ravens are generalists, primary poisoning may have been the cause. Seagulls and ravens are also scavengers and therefore are exposed to secondary poisoning as well. At the same time, since rats die underground they are not expected to be available for scavengers, and insects are not susceptible to anticoagulants. Therefore, impacts via secondary poisoning are expected to be minimal. However, a detailed and specific plan for each case, containing mitigation actions for both marine and terrestrial ecosystems, is obligatory. For example, during the black rat eradication in 2001–2002 on Anacapa Island, endemic mice were taken into captivity and raptors were temporarily maintained at a prudent distance from the island (Howald et al. 2005).

Following application, no traces of pellets or signs of negative environmental impact were found at the intertidal and sublittoral zone of FSI and SPM islands, and it appears that the deflector was successful in minimizing the number of bait pellets broadcast into the ocean. Consistent with other aerial rat eradications (Howald et al. 2005; Hoare and Hare 2006), marine invertebrate and fish communities did not appear to be negatively affected by the low amount of bait that fell into the water. No signs of poison-caused death were found in marine species. Helicopter disturbance to fauna was inconsequential, as the operation lasted only a few days and did not occur during the reproductive season for seabirds or pinnipeds.

Conventionally, formal protocols on rodent eradications establish that success can be declared after two years of the eradication, since rodents at low densities are difficult to detect (Howald et al. 2007). Post-eradication monitoring on these islands will continue seasonally, every three months. Once

the eradication is fully confirmed in fall 2009, the long-term monitoring will focus in those habitats and seasons where rats used to be more abundant. We expect post-eradication monitoring throughout 2009 to confirm both rat absence and ecosystem recovery. This project represents the first aerial broadcast rat eradication in Latin America and the second in North America.

Interinstitutional cooperation has been key to achieving the complex permitting, logistic, and financial challenges. The Mexican Navy, well above and beyond its mandate, has been actively engaged during the last years in island conservation projects (Aguirre-Muñoz et al. 2008). In this case, the Navy supported the helicopter operation by providing a modern vessel with helicopter platform and hangar as an in-kind donation. Also, the project got the backing from the Navy's facilities and the personnel on the mainland. The Ministries of the Interior (Gobernación) and Environment (SEMARNAT) have moved from a traditional regulatory and supervising role to a more proactive one (Aguirre-Muñoz et al. 2008). The teams in the field had the participation of technical personnel from the Protected Areas Commission (CONANP); for the CI-25 special bait importation, the CONANP's head, Ernesto Enkerlin personally assumed responsibility in front of customs and health authorities. This intense teamwork between a private organization and federal agencies is the result of trust and confidence gained during several years, honored commitments, and shared successful results. Because of the logistical complexities of working on islands, and once Mexican islands are federal territories, for future similar projects in Mexico the same commitment and support of Mexican government agencies is a must.

Based on what we can define as a focused collaboration approach, the "winning strategy" for eradicating 43 introduced mammal populations on 28 Mexican islands during the last decade integrates 3 main elements: (1) a persistent and capable private organization leading the process without distraction, free of bureaucratic limitations, and retaining its specialized personnel; 2) sufficient and timely funding coming from national and international sources; and 3) the proactive engagement of federal authorities. International collaboration has proven also to be important, as

other countries such as New Zealand have vast experience in this subject.

This particular eradication project will benefit many desert island plants and invertebrates, seven species of reptiles, more than nine species of seabirds, and fishing bats, and will represent an enormous advance regarding rat eradications in México. There are at least 20 more islands in Mexico where aerial procedures must be implemented in order to eradicate introduced rodents. Keeping and consolidating the current pace, the complete restoration of all 24 remaining Mexican islands with 60 populations of introduced mammals now appears to be a viable strategic goal that will be achievable by 2025.

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