Developing a Management Strategy to Reduce Roof Rat, *Rattus rattus*, Impacts on Open-Cup Nesting Songbirds in California Riparian Forests

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ABSTRACT: In 2001, roof rats were identified as major predators of open-cup songbird nests in old growth riparian forests of California's Central Valley. Nest predation was as high as 80%. For some bird species in recent years, the populations had declined, and their range was reduced. A management strategy to reduce rat impacts on songbirds was considered a priority. Following a review of the literature and consultation with land managers and experts in rodent management and bird conservation, we decided to reduce rat populations with poison baits delivered in bait stations immediately prior to the songbird nesting period. We subsequently conducted studies to provide information on rat home range and habitat use, potential baits, optimal bait station placement and distribution, and the potential non-target hazards of the program. The management strategy was then implemented in one riparian forest tract in October - December 2003. This is an adaptive management approach that will be evaluated in 2004, modified as necessary, and if successful, potentially applied to other riparian forests. In this paper we describe our approach to developing the management strategy, provide preliminary results, and discuss some of the potential problems with its implementation on a large scale.

KEY WORDS: baiting strategy, *Rattus rattus*, riparian forests, roof rats, songbird conservation

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INTRODUCTION

In California's Central Valley, many songbird populations have suffered declines and local extirpations over the last few decades largely as a result of habitat loss or degradation (Gaines 1974, 1977; Riparian Habitat Joint Venture 2000). Riparian habitat is especially important to many migratory songbird species breeding in California and has been identified as the single most important habitat for songbird protection and conservation (RHJV 2000). However, with less than 5% of riparian habitat remaining in California (Katibah 1984), suitable habitat patches are relatively small and fragmented. Studies of songbird populations and nest success in old-growth riparian forests suggest that nest predation may be the primary limiting factor in riparian forests, with predation rates as high as 80% for some open-cup nesting species in many years (Point Reyes Bird Observatory, pers. commun.). Under such high predation rates, local populations usually cannot be self-sustaining (Rogers et al. 1997).

In 2001, roof rats (*Rattus rattus*) were identified as the most common predators of songbird nests and were found to be abundant (trap success as high as 30%) in riparian forests on the Feather River, Yuba County; and Cosumnes River, Sacramento County, in the Central Valley of California (Whisson, unpubl. data). These observations, coupled with the observations of high predation rates on songbird nests, raised concern not only for songbirds, but also for other species such as wood ducks (*Aix sponsa*) that nest in riparian areas. Although management of these impacts was clearly needed, there were few examples of successful management programs on mainland systems on which to model a strategy. Most large-scale rat control programs have been implemented on islands where eradication is often feasible, the landscape mosaic is less complex, and there are fewer non-target hazards or they can be managed (e.g., temporary removal of non-target species). In riparian habitats, effective long-term management of rat impacts is limited by potentially high rates of reinvasion, poor access to densely vegetated areas, conflicts with other management goals, ecosystem complexity, and potentially high non-target impacts. The only successful strategies were implemented in forests in New Zealand (Innes et al. 1995), Hawaii (Nelson et al. 2002), and Puerto Rico (Whisson, unpubl. data) where impacts of rats on bird species are minimized by reducing rat populations with poison baits immediately prior to bird nesting periods. Because of the rapid recovery of rat populations following baiting programs, control measures must be implemented annually. We thought a similar approach might be effective in California riparian areas. Because of current regulations that prohibit aerial or broadcast applications of bait in non-crop habitats in California, we developed a baiting strategy that was based on the application of a registered anticoagulant bait in bait stations. We reviewed the literature, consulted with experts on rodent management and bird conservation, and conducted our own studies to provide the information needed to develop our baiting strategy.

DEVELOPING A MANAGEMENT STRATEGY

We conducted field studies in 3 riparian sites: the Audubon-Bobelaine Sanctuary on the Feather River, Yuba County; and 2 separate sites in the Cosumnes River Preserve, Sacramento County (Figure 1). These sites were chosen as representative of riparian areas that provide critical nesting habitat to songbirds. The

Audubon-Bobelaine Sanctuary site on the Feather River was located in a mixed riparian forest with a canopy dominated by cottonwood (*Populus fremontii*) and valley oak (*Quercus lobata*), and a lower stratum dominated by poison oak (*Toxicodendron pubescens*), wild grape (*Vitis californica*), native blackberry (*Rubus ursinus*), and Himalayan blackberry (*R. discolor*). The Cosumnes River Preserve comprises some of the largest remaining tracts of old-growth riparian forest in the Central Valley. These forests are typically flooded from December through March each year. Sites were located in large old-growth riparian forest tracts with canopies dominated by valley oak and cottonwood; mid-strata dominated by box elder (*Acer negundo*) and Oregon ash (*Fraxinus latifolia*); and lower strata dominated by poison oak, wild grape, native blackberry, and Himalayan blackberry.

Figure 1. Location of the study sites in the Central Valley of California.

In developing the management strategy, we considered the effects on control efficacy of size of treatment area, treatment timing, bait formulation, and bait station spacing. We also considered the potential primary and secondary non-target risks associated with baiting. Because our objective was to develop and assess the costs and effectiveness of an operational program, we took an 'adaptive management' approach and focused management (and resources) on just one large (15 ha) site in the Cosumnes River Preserve where songbird nesting information had been collected since 1996. Because the site was bordered by a slough on one side and the Cosumnes River on 2 sides, we considered that reinvasion of the site would be lower following treatment. While this design does not provide the benefits of replication, the results can be used to modify the strategy and adapt it for implementation in other areas.

Timing

Reducing rat populations immediately prior to and during bird nesting periods has proven successful in New Zealand (Innes et al. 1995), Hawaii (Nelson et al. 2002), and Puerto Rico (Whisson, unpubl. data). However, riparian habitats are often flooded during this period in California. We therefore decided to implement the strategy in October - November, with additional spring baiting if necessary to maintain populations at a low level during the peak songbird nesting period (March - June). Although we would be baiting several months before the onset of the nesting season, we speculated that rat breeding would be limited and population growth suppressed during the winter months when forests are flooded. Results from regular trapping in study sites in 2001 and 2002 supported this. In addition, natural food resources are less abundant during fall months, which may result in higher bait acceptance by rats. A baiting program at this time is also desirable in that there are few nesting birds that would be disturbed by personnel placing and monitoring the bait stations. We proposed to limit disturbance on nesting birds in spring by enlisting the help of field personnel who would simultaneously be conducting nest searches and bird observations.

Bait Station Spacing and Placement

In August and September 2002, we conducted a telemetry study to determine home range size, movements, and habitat utilization patterns of roof rats in the site to be treated. We trapped and radio-collared 12 adult roof rats from 5 different locations within the site. On one day per week for 8 weeks, we located the rats once during the day, and then at hourly intervals during the night. This study provided significant information relevant to the design of the baiting strategy:

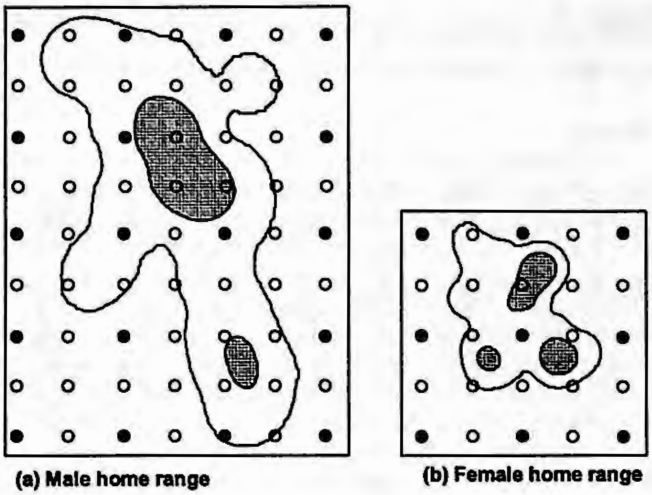
1) Rats nest in trees during the day but at night are active mostly on or near the ground,

2) Rats prefer locations of thick blackberry and grape vines,

3) Home ranges are highly overlapped between and within sexes, and

4) The mean home range of males was 0.78 ha and females was 0.45 ha.

We overlaid 25-m, 50-m, 75-m, and 100-m grids on home range maps to determine the optimal spacing of bait stations (Figure 2). Using a 25-m grid spacing, 11 of 12 rats would have access to between 1 and 7 bait stations in their core area, and all rats would have access to between 4 and 40 bait stations within their entire home range. Using a 50-m spacing, bait stations fell in the core area of only 3 of 12 rats, but between 1 and 10 bait stations were present in the total home range area of all rats. With a grid spacing greater than 50 m, many rats (especially females) would not have access to bait stations. While a 25-m grid placed more bait stations in core areas, we considered that this spacing would prove unfeasible in the field with 640 bait stations per 10-ha area compared to 40 bait stations for the 50-m spacing. We therefore chose a



- ● 50-m grid points
  - Male: 0 in core area, 5 in entire range
  - Female: 0 in core area, 1 in entire range
- o 25-m grid points
  - Male: 3 in core area, 24 in entire range
  - Female: 1 in core area, 6 in entire range

Figure 2. An example of male and female rat home ranges with 25-m and 50-m grids overlaid. Core use areas (50% of total activity) are shaded.

50-m spacing. Because rats spend much of their active time on or near the ground, we decided on ground placement of bait stations.

Identifying an Effective Bait

We tested 4 commercially-available diphacinone (0.005% active ingredient) bait formulations in laboratory tests for acceptance and efficacy. Ten rats per bait formulation were trapped in riparian areas and individually caged in an animal room in the Vertebrate Ecology Laboratory, UC Davis. For 10 days, we provided rats with cups of oats and bait and measured consumption of each daily. We recorded mortality during the feeding period and the subsequent 15 days. Following low acceptance and efficacy of diphacinone baits, we tested one chlorophacinone formulation (Rozol paraffin pellets, Liphatech, Inc.) (Table 1). This bait was well accepted by rats and resulted in 80% mortality. We therefore chose it for field use.

Evaluation of Primary and Secondary Non-Target Hazards

Primary Non-Target Hazards

We placed 10 bait stations containing bait throughout the area to be treated and monitored visitors with Trailmaster event recorders and remote cameras. Rats were the only visitors to enter bait stations, although raccoons (*Procyon lotor*) and opossums (*Didelphis marsupialis*) were also photographed beside stations. None of the stations were disturbed by these visitors. Although we did not record meadow voles or harvest mice at the stations, we consider these would be potential non-target species affected by the baiting program. However, because these species have relatively small home ranges, a high proportion of the population would not have access to bait stations spaced at 50 m, thus limiting the total population impact. House mice may also be affected by the baiting program, but because they are non-native, we were not concerned about impacts on this species. Eastern gray tree squirrels (*Sciurus carolinensis*) and Western gray tree squirrels (*Sciurus griseus*) have also been documented in the study area. The small bait station size used should preclude take of bait by these species.

Secondary Non-Target Hazards

In November 2002, we placed 10 rat carcasses in different locations of the forest. Visitors to carcasses were monitored with Trailmaster event recorders and camera units. Seven carcasses were scavenged within 7 days after their placement. Six carcasses were scavenged by opossums and 1 carcass by a red-shouldered hawk. Opossums removed carcasses up to 30 m away before eating them. Opossums may therefore be vulnerable to secondary poisoning, although we consider it unlikely that they would be able to find and consume sufficient carcasses to obtain a lethal dose. Red-shouldered hawks are not generally known as scavengers so were not considered to be highly vulnerable to secondary poisoning. This study will be repeated in spring 2004.

Table 1. Acceptance and efficacy of 4 diphacinone and 1 chlorophacinone bait formulations (0.005% active ingredient) for roof rats in laboratory tests (n = 10 per test).

Bait formulation	% Acceptance	Mean bait consumed/ animal/ day (g)	% Mortality
HACCO bait block[1]	10.0	0.8	50
JT Eaton bait block[1]	7.1	0.5	40
Agricultural Commissioner loose grain bait[1]	4.0	0.4	27
Agricultural Commissioner wax block[1]	1.5	0.2	0
Rozol Paraffin Pellets, Liphatech Inc. [2]	44.6	6.24	80

[1] Diphacinone 0.005%
[2] Chlorophacinone 0.005%

IMPLEMENTING THE BAITING STRATEGY

In October 2003, we used a GPS unit to locate and flag 49 bait station points on a 50-m grid in the 15-ha study area. GPS error and inaccessibility of some areas due to dense vegetation influenced the final placement of bait station points (Figure 3). We placed bait stations containing 200 g of bait at each baiting point on October 17. At each point, we attempted to place bait stations in areas of dense vegetation or debris where roof rats spend most of their time. We initially checked stations at weekly intervals, but when bait consumption increased, we checked and replenished stations at 4- to 5-d intervals until their removal on November 27. Heavy rains on November 29 resulted in flooding of the site in December. Bait consumption was high over the 38-d baiting period (Figure 4), with a total bait use of 24 kg. Only 2 stations were not visited at all during the baiting period. Bait consumption varied over time for the remaining stations with approximately one-half of the stations visited at each check.

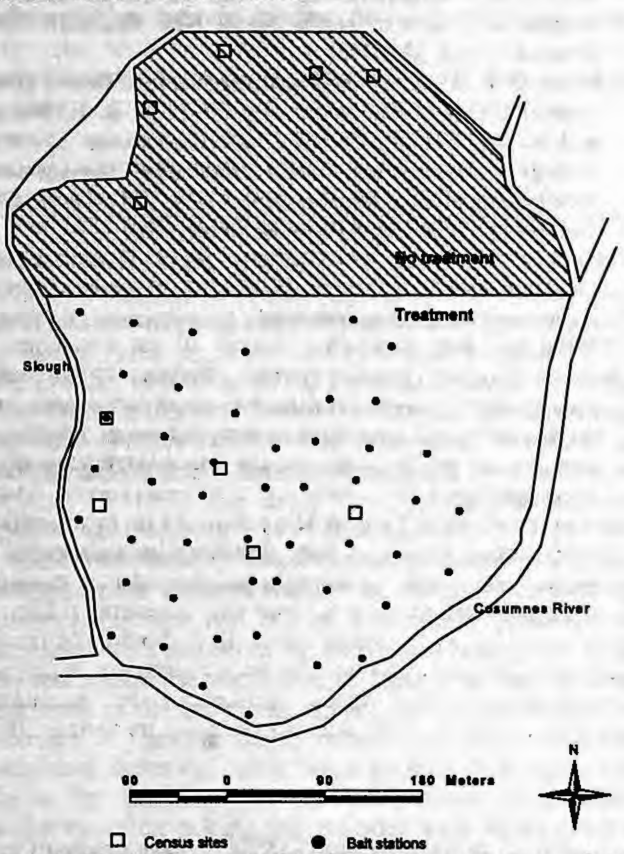


Figure 3. Final placement of bait stations and census sites in the treated and untreated areas of the Cosumnes River Preserve, California.

Based on the current market value of materials, amounts used, and labor required to treat our study area, we estimated the costs per hectare of the baiting program (Table 2). Although the cost is relatively high, a large proportion is the purchase of bait stations that could be reused in subsequent years. Labor costs would also be lower once permanent bait points have been established.

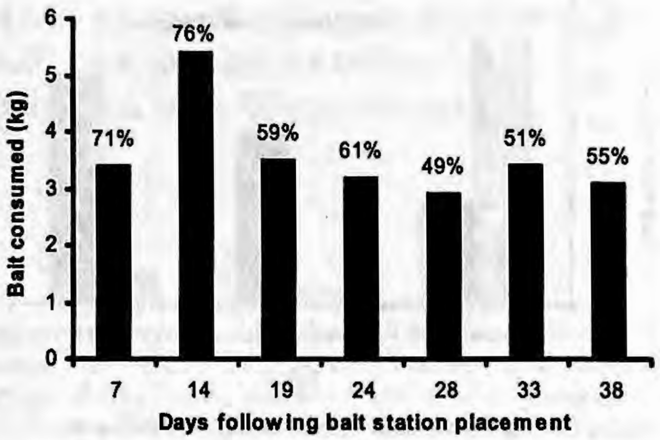


Figure 4. Bait consumed during the 38-d baiting period. The percentage of bait stations visited during the period since the previous check is indicated above each bar.

Table 2. Cost per hectare of implementing a baiting strategy in riparian forests.

Item	Cost ($)
Bait stations[a] (3.3/ha)	66
Bait[a] (Approx. $75 per 50-lb bag)	
1.6 kg/ha	5
Labor[b] (approximately $10 per person/hr)	
Setup (1 hr/ha)	10
Maintenance (7 checks x 0.5 h)	35
Pick-up bait stations (1 hr/ha)	10
Total Cost	126

[a] material costs are based on current retail value and may vary according to distributor, quantities bought, etc.
[b] does not include travel time to and from the site.

MEASURING THE SUCCESS OF THE BAITING STRATEGY

The true success of the baiting strategy can only be measured by comparing nest success in treated and untreated areas. In spring 2003, we conducted extensive nest searches in treated and untreated areas, and we documented the fate of up to 50 nest attempts in each area. This will be repeated in 2004. In addition, we censussed rat populations at each of 5 sites in the treated and untreated areas (Figure 3) prior to baiting, immediately following baiting in late November, and in January. In the short term, it appears that our baiting strategy was successful in reducing the rat population (Figure 5). To maintain the rat population at a low level, we will bait the area again during the bird nesting period. To minimize human impacts on birds during this period, personnel from Point Reyes Bird Observatory who are conducting nest searches and bird surveys in the area will monitor the stations and keep records of bait use.

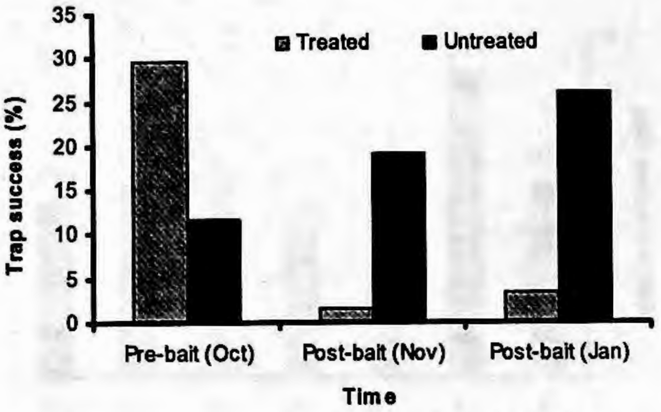


Figure 5. Trap success at census sites in treated and untreated areas prior to and following implementation of the baiting strategy.

FUTURE EFFORTS

Results from continued monitoring of rat populations and songbird nest success in 2004 will provide a basis for modifying the management strategy and adapting it for other areas. The major factors limiting the implementation of the strategy on a large scale are cost and the inaccessibility of many densely vegetated areas. If alternative methods (e.g., aerial baiting) are not feasible, it may be necessary to focus management on just some of the more critical nesting areas and on locations where rat population density is likely to be highest.

Development of this management strategy has implications for the conservation of not only songbirds in riparian areas, but also for other wildlife species and in other habitats where roof rats have become established. Due to the high reproductive and dispersal rates of rats, control must be undertaken each year (and possibly in fall and spring months), therefore requiring the dedicated support of land managers. Although costs of implementing the strategy may be high, they should be considered relative to the effectiveness of the program in conserving biodiversity.

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