A TEST OF THE JUDAS TECHNIQUE AS A METHOD FOR ERADICATING FERAL PIGS

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ABSTRACT: We conducted a trial of the Judas technique as a tool to eradicate feral pigs (Sus scrofa) from a reserve in Santa Clara County, California, USA. A hog-wire fence was constructed around approximately 1000 ha of the reserve, effectively creating an inland island. Three pigs were captured, radio-collared, and released as Judas pigs in an effort to eradicate a remnant population of an estimated 40 pigs. Trap success was affected by mast crop size and timing and by male dominance at bait piles. Using telemetry, we located pigs in less than 1 hr, compared with >4.1 hr without telemetry. Though our sample size was small, our results suggested that females made the best Judas pigs. We roughly estimated the number of Judas pigs required for the project by estimating home range sizes and dividing by the observed usable habitat within the enclosure. The Judas technique has been used with goats as a single method for eradication. It also works well in less social animals, such as pigs, but we recommend it as an adjunct to other proven eradication methods.

Key words: Eradication, feral pig, Judas technique, *Sus scrofa*

TRANSACTIONS OF THE WESTERN SECTION ON THE WILDLIFE SOCIETY 40:120-126

Feral pigs (*Sus scrofa*) have become a problem for public and private land managers in California (Sweitzer 1998, Waithman et al. 1999). In 1957, when the State Fish and Game Commission reclassified feral pigs as game animals, they were present in 10 counties (Waithman 1997); today they are present in 52 and still spreading (R. Loggins, pers.comm.) With a high fecundity rate and destructive feeding habits, pigs have a profound effect on landscapes and wildlife (Waithman et al. 1999). Rooting by pigs increases soil erosion (Lacki and Lancia 1983), resulting in siltation of streams and accelerated eutrophication of ponds. It also disrupts or dislodges vegetation, often killing grasses and seedlings (Becker 1985, de Nevers and Goatcher 1990, Aplet et al. 1991). Rooting yields bulbs, forbs, earthworms, and insects for pig diets (Henry and Conley 1972, Scott and Pelton 1975, Wood and Roark 1980, Baber and Coblentz 1987, Taylor and Hellgren 1997). In oak woodlands, pigs compete with native species for the acorn mast crop (Barrett 1982). Rooting and consumption of acorns may negatively effect the potential regeneration of oaks (Peart et al. 1994, Bruinderink and Hazebroek 1996, Loggins et al. 2002, Sweitzer and Van Vuren 2002). Pigs also eat grass seeds in large volumes in spring and early summer (Wilcox, unpublished data).

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In addition, pigs may be opportunistic predators (de Nevers 1993, Loggins et al. 2002). In Texas there have been documented sightings of pigs preying upon young goats and sheep, even cooperating in groups to kill adults (Littauer 1993). At our study site, diet analysis indicated that pigs actively preyed on a variety of vertebrates, especially rodents (Loggins et al. 2002, J. T. Wilcox unpublished data).

Given the conservation threat posed by feral pigs to California landscapes, control measures are warranted (Waithman et al. 1999). Rainbolt and Coblentz (1999) named 2 direct control strategies for feral animals: density reduction through occasional or annual sustained harvest, and full eradication. Complete eradication is the most desirable goal because it is the only reliable way to provide ecosystems with long-term relief from the impact of feral animals (Van Vuren 1992). However, complete eradication requires a considerable logistical effort and can be very expensive, because the last few animals can be very hard to locate and are usually quite wary (McIlroy and Gifford 1997). So far, only a combination of control methods has successfully resulted in true eradication (Sterner and Barrett 1991, Bryan 1994, McIlroy and Gifford 1997, Rainbolt and Coblentz 1999). Further, control programs must be carried out thoroughly and frequently, because feral pig populations have the potential to rebound very quickly (Rudge and Smit 1970, Van Vuren 1992). Control methods include trapping, poisoning (McIlroy and Gifford 1997), conventional hunting, shooting from a helicopter, and pursuit by hunting dogs (Van Vuren 1992).

At Hawaii Volcanoes National Park, Taylor and Katahira (1988) developed the "Judas" technique for finding the last few animals in an eradication program. The technique was developed for goats and took advantage of their gregarious nature. A feral goat is captured, fitted with a telemetry collar, and released. Its social nature compels it to locate other un-collared goats, which allows project managers to radio-track the animal to new groups. All goats in the group except the Judas are shot and the Judas is allowed to escape to find more goats. Some researchers were dubious that the Judas technique would be effective with pigs because they form smaller groups than goats (Soule 1990), but recent control programs in Australia and New Zealand suggest the technique has strong potential for pigs (Bryan 1994, McIlroy and Gifford 1997, Nugent 2002).

The Blue Oak Ranch, in Santa Clara County, is in the process of eradicating feral pigs. From 1998 through 2001 a pig-proof perimeter fence was constructed around a 1000-ha portion of the property, and pig numbers have been reduced to low levels by hunting. This provided the opportunity to investigate the Judas method for locating remnant pigs.

Our goal was to evaluate the efficacy of the Judas technique as a feral-pig eradication tool by determining the best number of Judas pigs per unit area, the most

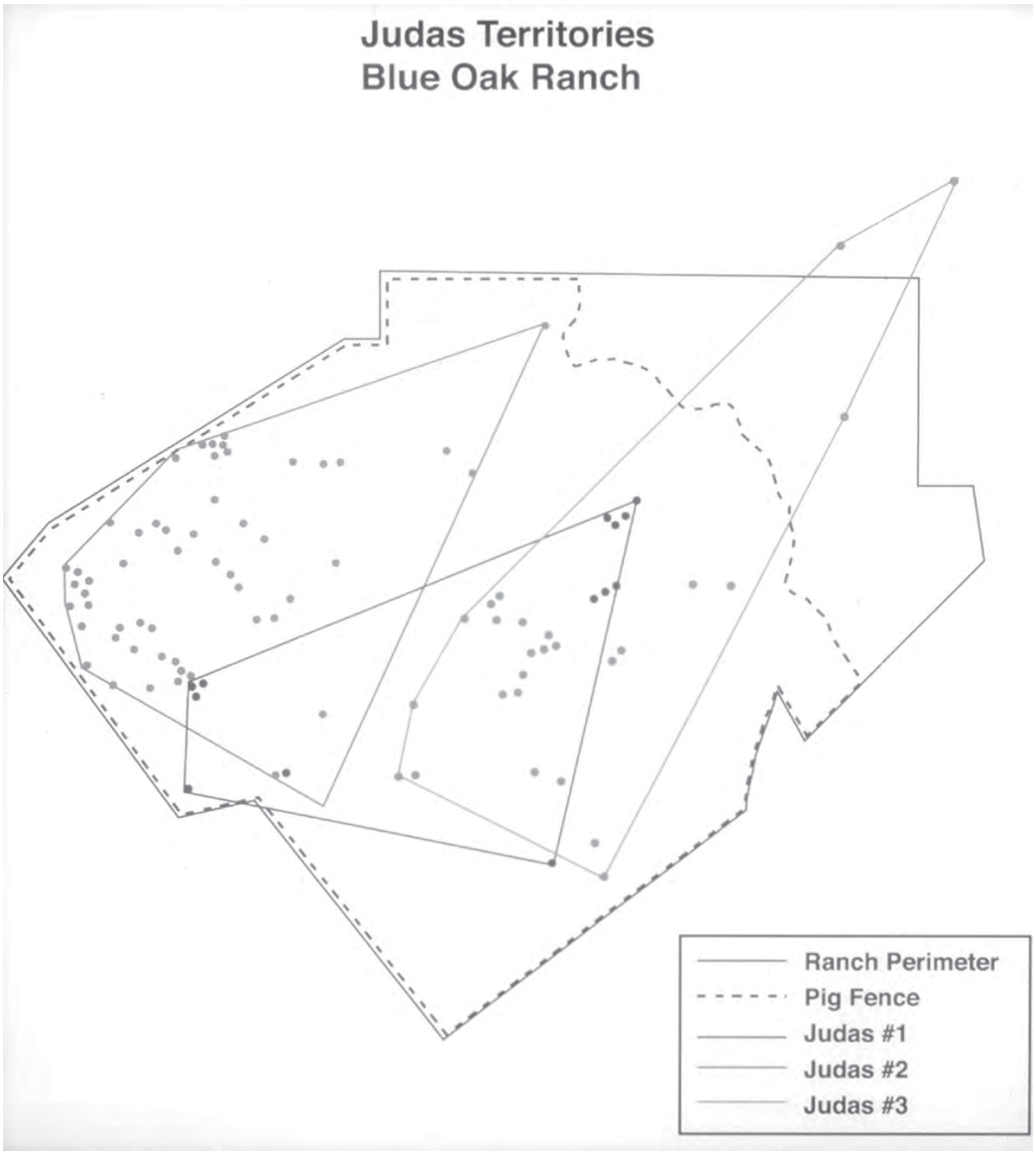

Figure 1. Territories of individual Judas pigs outlined using the minimum convex polygon method (Mohr 1947).

reliable gender for a Judas, the time required to find pigs with and without the use of telemetry, and the effectiveness of a Judas pig in locating remnant pigs.

METHODS

The study was conduced from February 2002 to July 2003 at the 1400-ha Blue Oak Ranch, situated in California's Diablo Range northwest of Mount Hamilton and 11 km east of San Jose. The ranch landscape is characterized by oak parkland and open grasslands interlaced with dense riparian habitats and dotted with patches of coastal sage-scrub. The ranch was used primarily for grazing for about 150 years. Cattle were removed in 1990, and since then the ranch has been managed as a private wildlife reserve. Feral pigs have been present there since the early 1980s (Wilcox and Serpa 2000).

During fence construction, pigs were shot on sight in an effort to reduce their population or haze them out of the area. In November 2001 the fence was completed, enclosing an area of approximately 1000 ha and effectively creating an "inland island." The fence measures about 16 km and is patrolled on foot approximately every 40 days to monitor fence integrity.

Pigs were captured using a box trap measuring 1 m wide, 2 m long, and 1.3 m high and constructed of heavy-gauge cyclone fence panels. Activity at the trap site was recorded with a remote camera (CamTrakker, Inc., Watkinsville, Georgia). Captured pigs were immobilized using a single-dart injection of Telazol and xylazine hydrochloride to keep stress levels low (Sweitzer et al. 1997). Each pig was checked for overall health, aged by its dentition (Matchke 1967), ear-tagged, fitted with a collar (Telonics, Inc., Mesa, AZ), and released once the sedative wore off.

Using telemetry, we recorded the time required to locate the Judas with a three-point triangulation, and noted the vegetation at the location, the time of day, and if any, pig activity was observable. Once the location of the Judas pig was established, we chose to either stake out the location and wait for an opportunity to shoot an associated pig with a high powered rifle, or we attempted to find un-radio-collared pigs elsewhere on the study area to hunt without telemetry. The choice was made based on the location and recent habits of the Judas group. If the group was in deep cover, and seemed unlikely to emerge before nightfall, we normally chose to hunt elsewhere without telemetry.

To estimate home range size we plotted triangulated positions on a topographic map and used the minimum convex polygon method (Mohr 1947) to calculate the area.

Table 1. Individual accounts of Judas pigs.

Judas number	Sex/age	Date collared	Duration as Judas
#1	Juv. male 16-22 mo	28 Feb 2002	~ 30 days
#2	Adult female > 3 yr	8 June 2002	197 days
#3	Adult male > 6 yr	11 March 2003	131 days

Table 2. Search effort and hunting success with, and without, telemetry for each Judas pig.

	With telemetry		Without telemetry		
Pig	Time to triangulate	Number killed	Visual encounter	Shot opportunity	Number killed
Judas #1	32 min	0	41. hr	8.4 hr	13
Judas #2	46 min	14	10.6 hr	18.5 hr	5
Judas #3	31 min	1	58.5 hr	58.5 hr	2

To compare hunting with and without the use of telemetry, we hunted pigs by driving the roads or hiking large sections of the study area, usually during the last few hours of daylight; these were the same procedures we had used before the Judas project began.

One or more pigs were considered a group. We recorded the number of hours between encounters with pig groups and between shot opportunities. Encounters are defined as the numbers of groups sighted or located by sound, at any distance, for any period of time. A shot opportunity is defined as an occasion when pigs are seen within a distance, and for durations, that would afford a high probability of a kill with a rifle.

RESULTS

Trap success was poor. At the time the fence was completed we estimated the pig population at 40 individuals. During the first year of the study, a year of poor acorn production, we captured 3 pigs in 4 attempts. During the second year, when acorns were abundant, we captured 1 pig in 23 attempts. We affixed radio-collars to 3 pigs (2 males, 1 female). We used 10 different trap locations and more than 1000 kg of bait in the trapping effort, but pigs were increasingly difficult to trap because of low densities. Direct observation and photographs from the remote camera suggested that mature males in mixed groups had dominance over most females at the bait sites. Only sows with piglets seemed dominant over boars. Male dominance at the trap may have prevented us from catching more sows.

Individual Accounts

The Judas pigs were collared sequentially, so no 2 pigs were radio-tracked simultaneously (Table 1). Upon release from the trap, Judas #1, a young male, initially stayed in nearby chaparral for 2 days in close association with a group of pigs that had been feeding near the trap. After a few days he moved away, never to be found with other pigs. Shots were never fired in the vicinity of Judas #1, but 3 times we saw him alone and subsequently flushed him from cover to give him the opportunity to locate other pigs. Judas #1 wore the collar for at least 30 days, but the collar was recovered laying on the ground. The condition of the collar gave no indication of the fate of Judas #1.

Judas #2, a female, was radio-tracked until we unintentionally shot her 197 days after capture (Table 2). Most of the pigs killed through radio-tracking were associated with this pig. The numbers of individuals observed with Judas #2 fluctuated over the first few months, but when numbers dropped below about 10 they began to steadily diminish. Despite the diminishing size of the group, Judas #2 seemed to be the nucleus. She was repeatedly observed with 2 young of the year, presumably her offspring, and with other adult sows.

Judas #3, a large adult male, was radio-tracked for 131 days. In that time we never observed him in association with other pigs. On 4 occasions we got very close to Judas #3 in a narrow, densely vegetated canyon to try to determine if he had other pigs with him. We never saw him in the dense chaparral, nor did we detect any other pigs. He left the reserve shortly thereafter through a breach in the fence. He returned through the same breach a month later, and we repaired the hole. Until the day he was killed, we never fired shots in his vicinity.

Hunting Efficiency

Hunting efficiency with radiotelemetry seemed to differ between males and females; the 1 female resulted in 14 kills with radio-telemetry and 5 without, whereas the two males totaled 3 kills with radio-telemetry and 15 without. Using telemetry, we could usually triangulate a position on the Judas pig in less than 1 hr. As we became more proficient, we were able to get a position in about half that time (Table 2). Hunting without telemetry, a minimum of 4.1 hr was required to find a pig.

Home ranges of Judas pigs averaged 330 ha, generally similar in size to those of feral pigs in similar habitats reported previously (Schauss et al. 1990, Sweitzer et al. 2000). The Judas pigs were usually found in dense chaparral and coastal sage-scrub in the northern portion of the study area. They were rarely detected in the southern portion, which has plenty of water and forage but little shrub cover.

Judas Pig Behavior

In response to methodical harassment, or hunting pressure, which involved rifle shots fired near them or making our presence known, the Judas pigs seemed to become more strictly nocturnal. Judas #2 had the most pressure exerted on her group. She was the only Judas pig that was fired upon multiple times, but the group usually didn't go far as a result. They typically returned to either of 2 chaparral thickets located about 500 m apart.

DISCUSSION

Sample sizes for our project were very small, but some inferences can be made. Females make the best Judas pigs, perhaps because the nuclear social unit is based around 1 to several females and their offspring (McIlroy and Gifford 1997). In our study, the 1 female seemed to form that nucleus. Each time the group was disturbed, most pigs in the group subsequently gathered with her. Other individuals associated with them, as was evident in the constant fluctuation in group size, but those individuals were primarily males, presumably seeking a female in estrus, or other social units temporarily mixing.

Our results indicate that male pigs make poor Judas pigs. Not once did we detect a male Judas in the presence of other pigs after it was released. Further, each time they were pressured by obvious human presence both male Judas pigs relocated to distant places, though neither was shot at. Singer et al. (1981) found that some males were less active than other males, with a home range 40% smaller than more active males, and were much less likely to engage a female in estrus. More active males had larger territories and were much more likely to engage females in estrus and other males in dominance struggles, but they avoided other pigs in times of non-estrus, making them useful as Judas pigs for only a small portion of the season. Contrary to our findings, McIlroy and Gifford (1997) concluded that males made more contacts with other pigs. However, they determined that females were better Judas pigs because they made contact with nuclear groups in far less time.

Our experience suggests that females may be more difficult to trap. Our observation that adult males are dominant at bait sites is consistent with the findings of Singer et al. (1981). They also found that adult males avoided females with young. This could explain why females with young appeared to be dominant over males at the bait site. Small trap size (our trap allowed for only 1 or 2 adult pigs to be captured at a time) and seasonal abundance of mast crops may also have contributed to poor trapping success. An alternative is to trap pigs elsewhere and bring them to the project location (McIlroy and Gifford 1997), but in California there may be concerns about moving pigs between areas. Further, McIlroy and Gifford (1997) discovered that Judas pigs from within the population being eradicated were much more effective than those introduced from a separate population, even when estrus was chemically induced in some of the sows from outside the population.

Behavior and daily activity regimes of pigs in our project were consistent with other studies. Pigs fed primarily at night, and in all seasons were more active in crepuscular and nocturnal hours, though they were more likely to exhibit diurnal activity in cold weather (Singer et al. 1981, Van Vuren 1984).

In our study, habitat use by collared pigs suggests the importance of large areas of dense cover in the selection of home range. Water was not a factor in determining home range size since it is available throughout the study area in all seasons. The portion of unsuitable habitat seemed to be about 100 ha and comprised the southern portion of the ranch where there is little dense shrub cover. To roughly estimate the number of Judas pigs required to adequately cover the enclosure area, we divided the suitable habitat (approximately 900 ha) by the mean home range size (330 ha). Researchers in New Zealand, tracking with helicopters, recommended one Judas per 2,000 hectares in open, unforested habitats (Nugent 2002). It may be useful to trap and collar pigs long before an eradication project begins to best determine the extent of usable habitat and the number of nuclear groups within a population. The most visible color for telemetry collars was yellow.

We found that feral pigs are "less gregarious" (Soule 1990, pp. 235) than the goats for which the Judas method was developed. Pig group size seemed to fluctuate widely at times. Despite small and variable group size, we found substantial merit to the Judas method. McIlroy and Gifford (1997) stated the technique has considerable potential, especially in small or isolated populations such as those in dense rainforest or nature preserves. Bryan (1994) reported a complete eradication of 47 pigs in a small, isolated population in the Northern Territory of Australia.
The strength of the Judas method lies in swift detection and location of pigs. Using the Judas technique we were able to locate pigs within less than 1 hour. Locating pigs without telemetry required a minimum of 4.1 hours when the pig population was at its maximum density, and required nearly 60 hours as the population declined near the end of the project. Detection doesn't guarantee an opportunity to eradicate, as pigs are often located in dense cover, but the Judas method can quickly place a tracker in position to make use of other eradication tools and methods. We conclude that, as an adjunct tool partnered with other proven methods such as normal hunting, trapping, helicopters, and/or hunting dogs, the Judas method is a useful tool in eradicating feral pigs.

ACKNOWLEDGMENTS

The Nature Conservancy's Santa Cruz Island Preserve provided funding for this project. We thank V. Scott for his help with trapping, B. Lockshaw for help in tracking, and D. Updike, M. Strauss, and T. Palmisano of the California Department of Fish and Game for their valued advice. N. Parizeau provided valuable comments on the manuscript. We are deeply grateful to the owners of the Blue Oak Ranch for their cheerful patience and permission to conduct this project.

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