Interim Control of House Mice Preying on Adult Albatrosses at Midway Atoll Prior to an Eradication Attempt

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***Abstract***

In December 2015, severe wounds were discovered on the dorsa of incubating albatrosses on Sand Island, Midway Atoll National Wildlife Refuge. Refuge staff used automatic cameras to document for the first time that birds were being preyed upon by non-native house mice (*Mus musculus*). Sand Island is home to 21% of all nesting Black-footed Albatross and 40% of all nesting Laysan Albatross worldwide. In 2016, mouse predation killed at least 42 adult birds, wounded 480 birds, and resulted in 70 abandoned nests in three distinct areas covering over 1.65 ha. This triggered a mouse control response to reduce mouse densities in the affected areas using multi-catch live traps, kill traps, and limited use of anticoagulant rodenticides in bait stations. In 2017, the extent of the affected areas increased to 11ha scattered over 50 sites resulting in 242 dead adults, 1,218 bitten birds and 994 abandoned nests. For the 2016-2017 albatross breeding season, we chose to hand broadcast a pelleted cholecalciferol rodenticide, AGRID3 (Bell Laboratories, Madison, WI), at a rate of 20kg/ha in all affected areas to reduce mouse populations while minimizing risk to non-target organisms. The casualties (mostly Laysan Albatross) represent a small proportion of the 360,000 pairs nesting on Sand Island. However, the risk to adult breeding albatrosses representing a large part of the global population prompted the Refuge to prioritize mouse control until an eradication can be completed. The bait applications were followed by a reduction in attacks and mouse detections using traps and sightings along transects declined after baiting in the larger treatment areas. No deleterious effects were observed in non-target organisms at the Refuge. Research, testing, and planning for a house mouse eradication project has begun. Until an eradication is complete, house mouse control using AGRID3 will continue during the vulnerable incubation stage of nesting albatrosses.

***Introduction***

Midway Atoll National Wildlife Refuge (MANWR), located in Papahānaumokuākea Marine National Monument, is home to the largest albatross colony in the world and is the most important and successful breeding ground for black-footed (*Phoebastria nigripes*) and Laysan albatross (*P. immutabilis*). Over 3 million birds of 29 species reside on Midway’s three islands. In December 2015, severe wounds were discovered on the dorsa of incubating albatrosses on Sand Island, MANWR. We used automatic cameras to document that birds were being preyed upon by house mice (*Mus musculus*) (Fig. 1). In the 2015-2016 breeding season, mouse predation killed at least 42 adult birds, wounded 480 birds, and resulted in 70 abandoned nests in three distinct areas across 1.65 ha of the 452 ha island. During the 2016-2017 breeding season, the extent of the affected areas increased dramatically to 11 ha scattered over 50 sites resulting in 242 dead adults, 1218 bitten birds, and 994 abandoned nests. Sand Island is globally significant, supporting 21% of all black-footed albatross and 40% of all Laysan albatross. The casualties (primarily Laysan albatross) represent a small proportion of the 360,000 pairs that nested on Sand Island (MANWR); however, the rapid scale-up of impact of mice (a 7x increase in area, 6x increase in dead adults, and a 14x increase in abandoned nests in one year) clearly demonstrated imminent risk to all adult breeding albatrosses at Sand Island if house mouse populations were not controlled or eradicated.

House mice were introduced to Sand Island more than 75 years ago and persisted after black rats (*Rattus rattus*) were eradicated in 1996. While mice have been implicated in albatross predation at two sites in the Southern hemisphere (Cuthbert and Hilton, 2004; Angel, Wanless, and Cooper, 2009; Jones and Ryan, 2009), this is the first time they have been documented killing adult albatrosses and the first occurrence in the Northern hemisphere. Hypotheses about the conditions that may have triggered this behavioral shift include emergence of unusual mouse behaviors and population fluctuations due to habitat changes during eradication of the introduced plant, *Verbesina encelioides*, at Sand Island. In addition, changes in rainfall patterns may have caused starvation in mice just as albatrosses laid eggs and were vulnerable to attack. Mouse populations are well known to fluctuate with rainfall (Jaksic, et al. 1997) and climate change may increase the frequency of El Niño–Southern Oscillation events (Timmermann et al.1999), exacerbating the risk to albatrosses. Mortality of breeding adult albatrosses immediately affects population growth by taking an active breeder out of the population, causing loss of that year’s egg or chick, and taking the mate out of the breeding population for at least one year subsequently, as it must form a pair bond with a new mate. Adult mortality has the strongest effect on population growth rates in species such as albatrosses with low fecundity, high age at first breeding, and prolonged parental care. The urgency to prevent adult mortality in albatrosses at Midway spurred MANWR staff to control mice immediately. In late 2015, a combination of live traps, kill traps, and a rodenticide in bait stations was used for control. In 2017, the team hand broadcasted a pelleted cholecalciferol product, AGRID3 (Bell Laboratories, Madison, WI), in all affected areas to maximize control of mice and minimize risks to Laysan ducks and migratory shorebirds. Experimental bait uptake trials led to the selection of 20 kg/ha as an effective application rate. The registered uses in the US were for agriculture so the USFWS worked with the Environmental Protection Agency and Bell Labs to develop a supplemental label to be attached to the label for AGRID3 Pelleted Bait (EPA REG. NO. 12455-117-3240) specifically for use by USFWS to control house mice on Midway Atoll in a wildland setting.

The rodenticide containing cholecalciferol was chosen specifically because Laysan ducks (*Anas laysanensis*), listed as Endangered under the US Endangered Species Act of 1973, and shorebirds, particularly Bristle-thighed Curlews (*Numenius taitiensis*), Pacific Golden Plovers (*Pluvialis fulva*), and Ruddy Turnstones (*Arenaria interpres*), protected by the Migratory Bird Treaty Act and commonly foraging on Sand Island might ingest the bait or insects that have consumed the bait. The bait product AGRID3, pellets contains 0.075% cholecalciferol (non-anticoagulant) which acts by disrupting calcium homeostasis by increasing its absorption from the small intestine and mobilization from the bones into the blood stream, as well as decreasing calcium excretion by the kidneys. Eason et al. (2000) found that mallard ducks fed cholecalciferol at a rate of 2,000 milligrams/kilogram were not affected and they stated that ducks would have to consume 2,000 g (4.4 lbs) of bait with this concentration to receive a lethal dose. Laysan ducks may consume some bait; however it is unlikely it will consume enough to cause injury. Also, the Laysan duck would not be able to consume enough bait to reach the lethal dose since it would need to ingest three times its body weight in pellets. The product Cholecalciferol has been proven to be toxic and effective to rodents, yet relatively safe to nontarget species if used according to label directions. Due to cholecalciferol’s unique mode of action and its attributes of no taste aversion and delayed toxic effect, it has been used in commensal rodent control situations and for field rodents (Marshall, 1984)

The aim of this study was to evaluate the efficacy of using AGRID3 pelleted bait for control of house mice to reduce predation on albatross during their incubation period.

**Objectives of management action and the study**

Fears of an escalation of mouse predation on adult incubating albatrosses from the rate in the previous year had motivated the acquisition of a supplemental label and a supply of AGRID3 so when the problem started again in December of 2016 when the birds returned to lay eggs and the number of affected areas increased from 3 to 50 and from 1.65 ha to 11 ha the decision to apply the bait was made. By the end of the incubation period in early 2017 there were 242 dead birds, another 1218 injured, and 994 abandoned eggs in the areas indicated on Figure 2. We commenced the application of AGRID3 with the following objectives:

Objective 1: To reduce attacks by house mice on albatrosses by treating areas where these attacks started occurring with AGRID3 Pellets, a cholecalciferol rodenticide product.

Objective 2: To minimize effects (mortality and disturbance) on all non-target species, including the federally listed (Endangered) Laysan duck and. migratory shorebirds during and after the implementation period.

Objective 3: To conduct pre- and post-treatment monitoring to measure changes in mouse density and attack rates on incubating albatrosses

***Materials and Methods***

In December 2016, as soon as most of the albatrosses had laid their eggs on Sand Island, Midway Atoll we initiated surveillance of the colony to detect a possible repeat of the mouse predation suffered the previous year. Observers searched for wounded birds and extraordinary levels of egg abandonment and mapped those areas. We surveyed plots 1, 4, 5 and the control area for dead adult albatross which were flipped ventral side up and marked to avoid double counting before and after each treatment. Abandoned eggs in a good nest cup were also counted and marked in those plots

Three baiting plots and a control that was not treated were monitored for the application done 19 December 2016 (Plots 1, 2, and 3) and 2 baiting plots were monitored before and after an application made on 20 January 2017 (Plots 4 and 5). To document mouse activity in all 5 plots and the control area before and after treatment with AGRID3 bait we used 6 multi-catch mouse traps per treatment area baited with peanut butter and measured number of mice captured one night before application, 1 night a week after the application and then 1 night 2 weeks after bait application.

In addition for plots 1, 2, 3, and the control area we walked a 150 meter transect after sunset and counted all mice seen within 2.5 meters of the path on either side between 7:30 and 10:00 PM immediately before the bait application and then 1 week and 2 weeks after the broadcast.

***Results***:

Mouse predation started again in December of 2016 and the number of affected areas increased from 3 in the previous season to 50 and from 1.65 ha of area in the previous year to 11 ha in 2017 (Fig. 2). By the end of the period of documented predation (19 February 2017) there were 242 dead birds, another 1218 injured, and 994 abandoned eggs which is a 6-fold increase in dead adults, 2.5 times as many injured birds, and 14 times as many nests abandoned as those in the previous year. The birds found dead were almost without exception Laysan Albatrosses rather than Black-footed Albatrosses.

All areas in which injured albatrosses and abandoned eggs had been detected were treated twice during the season (19 December and 20 January) except for one 0.5 ha control plot. Figure 3 shows all 50 treated areas totaling 11 ha. The rate for most of those areas was 20 kg/ha thrown by hand in a 5 meter baiting grid. Each application took 17 people 2.5 days to treat the entire area.

Mouse detections – Zones 1,2,3 showed a reduction in the number of mice trapped and seen after treatment while the control site increased in December. Trapping in Zones 4,5 done a month later before and after the second treatment showed a different pattern with mouse numbers increasing after treatment (Fig. 4). Mouse detections on 150 meter transects through the treatment areas declined in plots 1.2, and 3 after the application of AGRID3 and remained much the same in the control plot (Fig. 5).

Numbers of newly dead adults and abandoned nests diminished after each bait application in plot 1 (Fig. 6) but the effect in plots 4 and 5 were minimal (Fig. 7). Dead adults and abandoned nests detectionsincreased in the Control area (Fig. 8)

There were no observations of any non-target organism such as shorebirds or Laysan ducks interacting with bait pellets in the field or being found sick or dead in the colony.

***Discussion*:**

Two differences between these two trials that might explain the different response in terms of mouse captures or detections 1 and 2 weeks subsequent to bait applications were that zones 1, 2 and 3 were much larger in size than zones 4, 5.

Smaller treatment areas had ambiguous results with an increase in mouse detections occurring after treatment. In a food limited environment mice may have been attracted by the bait and the edge effect on immigration may have elevated mouse density in the plots. The measurements of mouse numbers before and after were made at different times of the mouse population cycle and under different rainfall conditions.

***Conclusions:***

**A reduction of mouse detections, newly dead adult albatrosses, and abandoned eggs was observed after broadcast applications of AGRID3, a cholecalciferol rodenticide product, in treatment areas larger than 1.2 ha.**

**There was no evidence of negative effects on non-target organisms such as Laysan ducks and shorebirds during the management action.**

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Figures

Figure 1. Introduced house mouse attacking adult Laysan Albatross as it incubates as captured by a Reconyx trail camera.

Figure 2. Areas in which mouse impacts (dead adults, wounded adults, abandoned eggs) were detected in the 2016-2017 albatross breeding season.

Figure 3. Areas treated with AGRID3 at a rate of 20 kg/ha on 19 December 2016 and 20 January 2017.

Figure 4. Numbers of mice trapped before and 1 and 2 weeks subsequent to applications of cholecalciferol rodent bait in areas 1,2, 3, 4, and 5, and a control site.

Figure 5. Numbers of mice counted on a 150 meter transect (2.5 meters to each side prior to and 1 and 2 weeks after application of cholecalciferol bait in plots 1,2, 3 and a control site.

Figure 6. Numbers of new detections of abandoned eggs and dead adults in plot 1 throughout incubation period of breeding Laysan Albatrosses at Midway Atoll. Cholecalciferol in pelleted bait was applied on 19 December 2016 and 20 January 2017 at a rate of 20 kg/ha and plot was surveyed for new injuries, mortality, and nest abandonment approximately every 3 days.

Figure 7. Numbers of new detections of abandoned eggs and dead adults in plots 4 and 5 immediately before and 1 week and 2 weeks after bait application.

Figure 8. Numbers of new abandoned eggs and dead adult albatrosses in a control plot in which no rodenticide was deployed over a 2 week period in December of 2016.

Figure 9. Area in square meters of each of 5 plots in which AGRID3 was broadcast and a control.

Figure 10. Rainfall in cm for each of the 4 months spanning the study.