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Controlling Roof Rats on Poultry Farms using ContraPest, A Contraceptive Bait

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ABSTRACT: Roof rats and other rodents are a common pest in agriculture, causing extensive amounts of damage and losses. Poultry farms provide an abundance of resources that attract rodents but our ability to control them in these locations is limited. Bait stations can become sources of nesting or go unused if the target species only travels in aerial locations. Any uncontrolled rats will quickly overpopulate agricultural buildings due to their high reproductive rates. We tested alternative baiting devices at a large poultry farm to develop a station that was easily utilized in aerial locations and well accepted by roof rats. We deployed ContraPest®, a contraceptive liquid bait, in the devices and tracked consumption monthly. We monitored the rat populations for 16 months with remote cameras to measure changes in activity before and during ContraPest baiting using a general index approach. Linear regression showed a significant relationship between ContraPest consumption and the general index. As rats continuously consumed ContraPest from the new baiting devices, activity steadily declined. Within one year of using ContraPest, rat activity reduced by 94%, showing a significant difference from starting activity levels. These results demonstrate the impact an antifertility agent can have on rat populations when used successfully within an integrated pest management program.

KEY WORDS: antifertility agent, bait device, contraceptive bait, ContraPest, field trial, poultry farms, *Rattus rattus*, reproduction, roof rats, vertebrate pest control

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INTRODUCTION

Livestock production continues to feed a growing human population, making up 17% of the calories consumed globally and 33% of all protein uptake (Thornton 2010). By 2050, the global human population is estimated to exceed 9 billion. To meet the demand of a growing population, farming will need to increase production volume at an even greater efficiency. The consumable food supply will need to expand by 70% which will require not only higher yields, but reduced losses from producer to consumer (Cole et al. 2018). One way to mitigate losses is to decrease damages caused by pests, including rodents.

Rodents are particularly problematic for poultry farms. Rodents cause damage to infrastructure and equipment, contribute to feed and egg loss, and prey on pullets (Witmer and Shiels 2018). Pimentel et al. (2000) estimated one billion rats across all poultry farms in the U.S., with each rat causing $15 of damage a year, or $15 billion collectively. Rodents are also a major health concern for poultry farms due to contamination from rodent-borne pathogens, such as *Salmonella* Enteritidis (Backhans and Fellstrom 2012). These operations are subject to strict inspections; the presence of rodents or confirmed disease interrupts production and is costly (Mohan Rao and Sakthivel 2015).

An integrated pest management (IPM) approach is imperative in agricultural settings for the health of the animals, employees, and business. In poultry facilities, the most successful rodent control is achieved during flock turnover when the poultry houses undergo deep cleaning. During this short period when the houses are empty, feed is no longer provided and rodents become desperate for food, making them easier to trap and bait. However, once the birds return and a normal food supply is offered again, any remaining rodents will quickly repopulate due to their fecundity (Loven 2010). Adding an antifertility agent could help these facilities maintain low numbers after a population knockdown. ContraPest®, a liquid contraceptive bait registered for use on Norway rats (*Rattus norvegicus*) and roof rats (*R. rattus*), prevents fertility in both sexes and can be used in tandem with other products to reduce rat populations.

A large poultry producer in the Tampa Bay area of Florida introduced ContraPest into their IPM program after all previous attempts to maintain control over the rat population had failed. Prior to ContraPest, the farm reported losses of 2,000-3,000 pullets per flock due to rat predation, equating to approximately 3-5% of their total birds. This loss was detrimental to their egg supply, as pullets eventually grow to become layers. In addition, they estimated $250,000-$500,000 in feed loss annually, as well as damage to cooling pads, conveyer belts, wires, and insulation caused by rats (SenesTech, unpubl. data). After using ContraPest for a year during flock turnover, the farm reported no additional damages, reduced feed loss, and an 88% improvement in pullet shrink.

The data reported shows how valuable an antifertility agent is in livestock farming. While successful results were achieved, providing bait in stations was a challenge. The farm could only get rats to consume when the birds were removed, and feed was absent from houses. Poultry farms provide plenty of feed, making bait stations less desirable or convenient options for rodents to explore. When rats were observed using bait stations, they often became nesting sites, which could create biosecurity issues. In addition, many farms are battling roof rats, and stations may not reach this predominantly aerial species (Marsh 1994).

Due to the challenges of bait stations in poultry and other livestock farming operations, our primary objective was to find an improved baiting device for ContraPest that would offer a variety of placement options and be well accepted by rats. The secondary objective was to evaluate the performance of ContraPest, when delivered in such device, by measuring consumption and monitoring changes in the rat population using a general index approach with motion-activated cameras (Engeman 2005, Engeman and Whisson 2006, Rendall et al. 2014, Lambert et al. 2018).

METHODS

Study Site

A field trial was performed at an egg production facility in California that has a total of nine poultry houses. Each house is roughly one acre in size (500 ft by 90 ft); adjacent houses are approximately 150 ft apart from one another with a connecting conveyor belt that transports eggs to a processing area. Each house contains two floors where egg laying hens are housed and an attic. Four of the nine houses at the farm were baited with ContraPest, while the remaining five were empty of birds due to construction. After confirming that rats were absent in the empty houses, they were omitted from the trial.

At the four operational houses, rats were primarily observed nesting in the attic, and they would travel down to the poultry floors in the evening to access feed and water. Prior to implementing ContraPest, rat infestation levels varied by house, ranging from low to high. Despite the differences in rat activity, the potential for migration between adjacent houses could not be ruled out so data were analyzed collectively.

Rodent Control Program

The site manages their rats with IPM practices, including exclusion, sanitation, trapping, removal, and chemical control via rodenticides. Standard operating procedures for rodent control continued at the site during the trial and the only change made was the addition of ContraPest. Rodenticides were actively used alongside ContraPest and monitored by the pest management professional and farm independently. Thus, consumption of rodenticides was not monitored by SenesTech personnel, nor was this information provided before or during ContraPest baiting.

Pre-Treatment: Assessment of Baiting Devices

Before ContraPest baiting began at the site, a liquid placebo product was offered in three different devices for seven weeks to determine which provided the greatest placement options and highest consumption. The first device tested was a one-gallon bucket with multiple drinkers that allowed for simultaneous consumption. The second device was a square bottle (16 fl oz) with a single drinker attachment, and the third device was the J.T. Eaton Top Loader™ (JTE) that held a liquid bait bottle (16 fl oz).

The buckets (n = 22), square bottles (n = 37), and JTE devices (n = 39) were placed in the front and back of chicken enclosures, near conveyor machinery, in the attics, on structural beams, rafters, ledges, and ceiling channels. Each device was tested concurrently in two poultry houses to ensure consumption was not biased to favor one over another. Consumption was measured biweekly using a food scale to record weights (g) and totals were compared between devices. The two devices that received the least amount of consumption were removed from the trial, while the device with the greatest overall consumption was selected for ContraPest baiting.

Treatment: ContraPest Baiting

ContraPest baiting began in October 2019 and continued through February 2021. ContraPest was provided monthly to maintain a fresh supply of bait. The amount of ContraPest applied was recorded at each device during the monthly replenishment. To measure consumption, device weights (g) were collected before and after the bait was replaced. Devices were initially deployed across all four poultry houses in similar locations used during the pre-treatment period and were removed or relocated if less than 100 ml was consumed for two or more consecutive months.

Rat Activity General Index via Camera Traps

Infrared motion sensor cameras (Reconyx HC600, Reconyx, Holmen, WI) were used to measure changes in rat activity prior to and during ContraPest baiting by calculating a general index (GI) using the daily rat observations. Cameras were not authorized to be used on the poultry floors due to privacy concerns of the farm. Thus, at the request of the farm, cameras were only placed in the attic. One camera was placed in attic of each house (n = 4) and remained in position for the duration of the trial.

Camera data were collected between September 2019 and February 2021. Camera trapping surveys occurred every 30 days for a duration of four consecutive 24-hour trap days (De Bondi et al. 2010, Lambert et al. 2018). A pre-treatment survey was completed during device testing in late September 2019 to measure starting rat activity levels. The first treatment survey began in early November 2019, exactly one month (31 days) after ContraPest was deployed.

Cameras were secured to stands made of PVC pipe and positioned horizontally at a height of $\geq$1 m (De Bondi et al. 2010, Smith and Coulson 2012). All cameras were placed at a maximum distance possible from any bait ($\geq$25 ft) to ensure unbiased activity. The cameras were programmed with a 30-second delay between triggered events to reduce the likelihood of capturing the same rat (De Bondi et al. 2010, Lambert et al. 2018). The number of images containing at least one rat were calculated for each 24-hour trap day to get the number of unique events for the GI value (Engeman 2005). The number of individuals were counted when multiples were observed.

Data Analysis

Bait consumption was calculated as the difference in device weight (g) each month. The differences in overall consumption between the three devices tested in the pre-treatment period were determined by One-Way ANOVA with significance set at 0.05. To measure device performance during the treatment period, bait acceptance rates were calculated as the amount of ContraPest consumed divided by the amount applied. To ensure that the removal of devices over the treatment period did not impact the opportunity for consumption, we computed a Pearson product-moment correlation coefficient to investigate the relationship between bait acceptance rates and number of devices deployed.

To measure activity changes in the rat population, the mean number of unique camera events was calculated for each trap day within our survey period and the mean of the daily means provided the GI value (Engeman 2005). A t-test was used to determine if there was significant difference in unique rat events before and after ContraPest. Simple linear regression with a statistical significance based on $p < 0.05$ was used to predict the GI of rat activity based on ContraPest consumption.

RESULTS

Baiting Devices

Square bottles had the greatest consumption of placebo bait (4.2 L), followed by gallon buckets (1.6 L), and lastly JTE (0.62 L; Figure 1). There was a significant difference between all groups ($p = 0.0019$; Table 1). Square bottles allowed for the most placement options, especially in elevated, low-clearance locations. Based on these results, gallon buckets and JTE options were discontinued for ContraPest baiting.

ContraPest Consumption

Rats consumed 57.71 L of ContraPest between October 2019 and February 2021 at the four poultry houses (Figure 2). Total monthly consumption ranged from 1.4-6.9 L (Table 2) and trends showed a significant change in mean consumption in March 2020 (234%) and August 2020 (218%) compared to previous months (Figure 3).

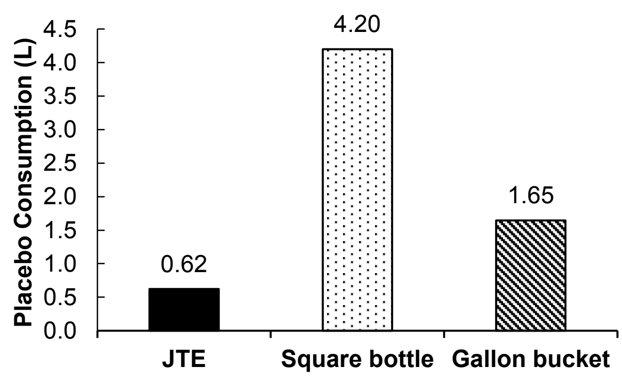

Figure 1. Total consumption (L) of placebo bait from three different baiting devices tested for seven weeks during pre-treatment period between August and September 2019.

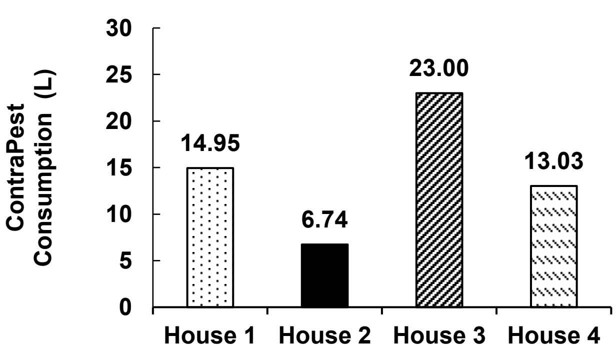

Figure 2. Total ContraPest consumed (L) at each of the four treated poultry houses during the treatment period from October 2019 to February 2021.

Table 1. Total placebo bait consumption (ml) from J.T. Eaton Top Loader™, square bottle (16 oz), and gallon bucket devices between August and September 2019. Significant difference in consumption between all devices based on ANOVA.

Device	Total (ml)	Mean $\bar{x}$	95% CI	P Value
JTE	623	15.97	21.56	0.0019
Square Bottle	4,199	113.49	43.23	
Gallon Bucket	1,645	74.73	70.93	

Table 2. Monthly ContraPest summary for all treated poultry houses, including number of baiting devices, total consumption (L), mean consumption (L) per device, and the mean bait acceptance rate per device (%) from October 2019 to February 2021.

Month	Baiting Devices (n)	Total Consumption (L)	Mean $\bar{x}$ Consumption (L)	Mean $\bar{x}$ Acceptance Rate (%)
Oct-19	68	2.19	0.032	0.06
Dec-19	66	2.74	0.041	0.07
Jan-20	62	3.72	0.060	0.11
Feb-20	48	2.11	0.044	0.08
Mar-20*	39	5.73	0.147	0.27
Apr-20	36	6.99	0.194	0.35
May-20	34	4.20	0.124	0.22
Jun-20	36	3.13	0.087	0.16
Jul-20	33	1.41	0.043	0.08
Aug-20*	45	6.13	0.136	0.27
Sep-20	34	4.96	0.146	0.28
Nov-20	32	5.32	0.166	0.36
Dec-20	30	3.56	0.119	0.27
Jan-21	25	3.09	0.124	0.29
Feb-21	22	2.43	0.111	0.24
Overall	***41***	***57.71***	***0.095***	***0.18***

*Significant change (increase) in monthly consumption from month prior.

A total of 68 devices were deployed between all the houses at the beginning of the trial. This number was reduced over time as devices with low consumption were removed. After six months of ContraPest baiting, the number of devices had been reduced by 50% (n = 34). Upon the second year of treatment, roughly 30-35% (n = <25) of devices remained across all four houses. A Pearson's correlation was run to determine the relationship between the number of devices deployed and bait acceptance rates. Results showed a strong, negative correlation between the variables, $r(13) = -0.67$, $p = 0.005$ (Figure 4).

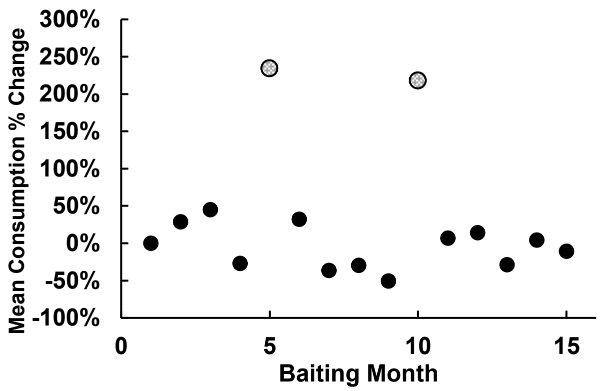

Figure 3. Percent change in monthly mean consumption from October 2019 to February 2021. Two significant increases occurred: March 2020 (Month 5, 234%) and August 2020 (Month 10, 218%).

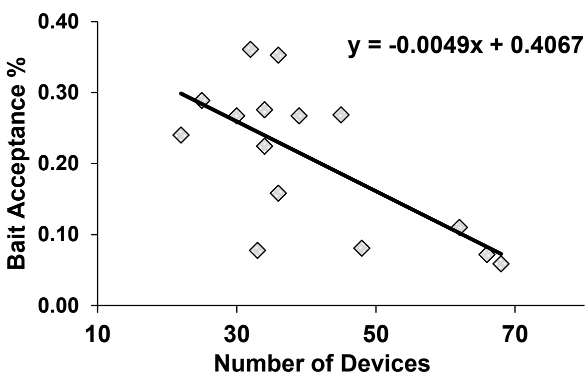

Figure 4. Scatterplot showing relationship between number of devices deployed and bait acceptance rates with regression line and corresponding 95% confidence intervals (r = -0.67, p = 0.005).

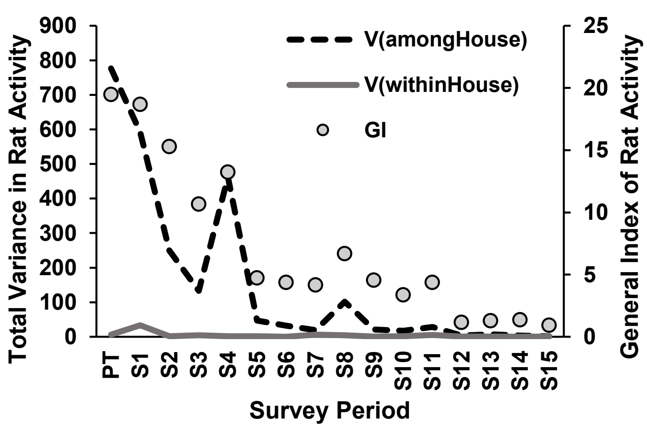

Figure 5. Total variance in rat activity (among and within houses) and GI values across surveys carried-out between September 2019 and February 2021; PT = pre-treatment survey (September 2019).

Table 3. Camera data summary comparing quarterly trends in rat activity, beginning with the pre-treatment (PT) survey (September 2019), and ending with the final survey (S15) completed in year two of ContraPest treatment (February 2021).

	Pre-Tx	Tx-Year 1				Tx-Year 2
Survey Period.	PT	S3	S6	S9	S12	S15
Unique Photos	312	171	70	73	19	15
Total Rats	349	178	70	73	19	15
General Index (GI)	19.50	10.69	4.38	4.56	1.19	0.94
GI % Change	*N/A*	*-45%*	*-78%*	*-77%*	*-94%**	*-95%**

*Significant change in rat activity (p < 0.05) since the pre-treatment survey period.

Camera Sampling Effort

Camera traps collected a total of 2,325 images over 256 trap days. From these total images, 78% contained at least one rat for a total of 1,833 unique events. The number of individuals counted in the unique photographs was 1,933 rats. Rats were detected at all cameras (M = 30 rats/camera) and no other animal species were recorded.

Rat Activity

The GI of rat activity was highest during the pre-treatment survey (September 2019) and steadily declined throughout ContraPest baiting (Table 3). At one year of ContraPest baiting, rat activity reduced by 94% and there was a significant difference from the pre-treatment survey, $t(15) = 2.48$, $p = 0.025$. Rat activity plateaued into the second year of treatment with GI values approaching zero (<1 rat event per camera trap day).

The total variance in rat activity (within and among poultry houses), was plotted alongside the GI values for each survey (Figure 5). This demonstrates similar variance within houses and high variability among houses at the beginning of the trial. After repeated ContraPest consumption, variance among houses began to decrease and all houses converged toward zero in the same way.

A simple linear regression was calculated to predict rat activity based on ContraPest consumption. The overall regression was statistically significant, $R^2 = 0.65$, $F(1, 14) = 125.76$, $p < 0.001$. It was found that ContraPest consumption significantly predicted rat activity ($\beta = -0.0909$, $p < 0.001$). The slope coefficient for ContraPest consumption predicts that for every additional ml consumed, the GI of rat activity would decrease by 0.09 (Figure 6).

DISCUSSION

Roof rats are a common pest in poultry and other agricultural operations, but our ability to control them in these environments is limited. Farms provide ideal conditions for rodents but getting them to explore stations and/ or consume bait can be a challenge when resources are abundant. Large scale knockdown efforts are common, but any remaining rats will quickly repopulate. To combat population growth of roof rats at a poultry farm, we wanted

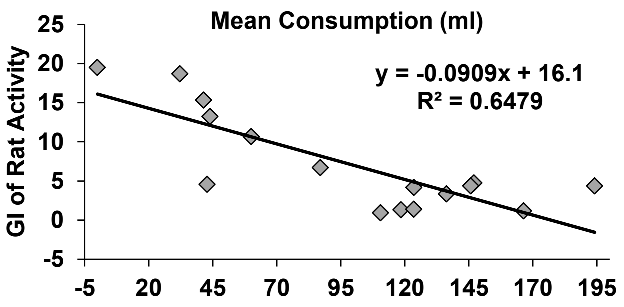

Figure 6. Scatterplot of the GI of rat activity (mean unique photos) and mean ContraPest consumption (ml) with regression line and corresponding 95% confidence intervals (R2 = 0.65, p < 0.001).

to identify a device from which rats would repeatedly consume ContraPest when bait station use was a challenge.

Early in the study we tested three devices. Based on consumption, it was determined that square bottles were preferred by rats and allowed for better placement in areas where roof rats frequent. These devices were then selected for ContraPest baiting. Between October 2019 and February 2021, rats drank from square bottle devices at all poultry houses each month, consuming a total of 58 L of ContraPest.

To optimize use of our selected device, improvements were made to increase bait acceptance and performance. Percent change in mean consumption showed significant increases when amended drinkers were tested on the devices in March and August 2020, suggesting that these changes were positively accepted by rats. As we increased bait acceptance in some devices, we also learned which baiting locations rats preferred and removed devices with lower consumption rates. Our results showed that decreasing the number of baiting devices did not reduce bait acceptance, and in fact, reducing the number of devices correlated with increased bait uptake, $r(13) = -0.67$, $p = 0.005$. By removing lower performing devices, we may have helped increase consumption at remaining devices.

We found a significant relationship ($p < 0.001$) between monthly ContraPest consumption and monthly rat activity ($R^2 = 0.65$). As consumption increased over the trial, rat activity continued to decline. Activity levels reached a significant decline [$t(15) = 2.48$, $p = 0.025$] within one year of ContraPest baiting and remained at low, stable levels into the second year of treatment. By the final survey, the rat activity GI value showed a 96% decrease compared to the pre-treatment survey. Variance among poultry houses showed a reduction after repeated ContraPest consumption, with each house approaching zero activity in a similar manner, signaling fertility control as a driver of change at the site.

The addition of ContraPest at a poultry farm successfully reduced rat activity to levels that had not been achieved prior. Lethal methods removed rats, while ContraPest prevented reproduction in survivors and kept the rat populations low. These results show how fertility control can enhance an IPM program to provide greater control over rats in food production, helping towards a more stable and secure food supply.

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