

TRANSONIC PRO Sonic/Ultrasonic Units Reduce Mouse Problems in Home

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ABSTRACT: Mice in homes leave droppings and urine and are vectors for Hanta virus and Lyme's disease. This study tested whether ultrasounds from a TRANSONIC PRO, Bird-X Inc., Chicago IL, (hereafter T-PRO) significantly reduced mouse problems in an old farm house. One T-PRO was used on "quiet volume" (frequency range 20 kHz-45 kHz at 72 - 78 dB @ 0.5 m) for all tests. Three paired tests were conducted, one pair for identical periods of autumn for 2009 and 2010, two for full year cycles 2012 to 2013, 2013 to 2014, 2015 to 2016, and 2016 to 2017. Efficacy was assessed using indirect evidence of ultrasound detection/avoidance by mice based on absence of mice trapped in the house or droppings counted on kitchen counters during test periods when the T-PRO was "ON" versus similar counts when the T-PRO was "OFF." Mice were free to leave the areas of the sounds and the house entirely, and thus failed to evidence habituation. In all years six peanut butter baited Victor brand snap traps were kept on the top three basement steps below the 2.5-m × 1.1-m entrance hall extending from the exterior door to an inner hall door. The latter was kept closed, but had a 1-cm gap under it that permitted mice to enter the kitchen area. In the three test periods when the T-PRO ultrasonic sounds were being broadcast, nine mice were caught and 14 droppings found on the kitchen counter; versus 91 mice caught and 154 droppings counted when the T-PRO was turned "OFF." A two tailed T-Test indicated a $P = 0.0007$, $T = 9.2998$ $df = 4$, with a mean of 30.33 mice caught/test cycle with the unit "OFF" versus a mean of 3.67/cycle when it was "ON." No changes were made in house/hallway during this study. Seasons tested matched precisely for multiple years reducing probability that annual variations in mouse populations near the house might have caused random spikes in mouse numbers trapped. Snap traps and the T-PRO presented an effective integrated pest management system resulting in a nearly mouse-free house.

KEY WORDS: Integrated Pest Management, *Peromyscus maniculatus*, ultrasound pest repeller, ultrasonic sound

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INTRODUCTION

Mice damage homes by gnawing on wiring or baseboards, nesting in drawers and closets, and contaminating food supplies. They leave abundant droppings mixed with strongly scented urine, especially in their nests. Mice are known vectors for the human sicknesses, hantavirus and Lyme disease. Mice in a house gnaw on soap, drown in toilets, leave droppings on counters, stoves, silverware in drawers, and on floors. In old homes, and restaurants it requires continual effort to clean up after the little rodents. As a result, most humans willingly trap or poison mice in homes. People have sought the perfect mousetrap for centuries, but most people would prefer not having to empty such traps too often. They want a simple means to keep mice out of their homes. Sonic and ultrasonic frequency sound generating devices offer a relatively untested or poorly tested method to keep mice out of homes. Past tests reported ultrasound to be ineffective or only partially effective in repelling mammals, including bats, (Hurley and Fenton 1980), and rodents (Meehan 1976, Lund 1984, Schumake et al. 1984, Munro and Meehan 1987, Bomford and O'Brien 1990). This study was designed to evaluate the efficacy of one such device when used within its known limitations in reducing mouse presence and evidence in homes with as little human time and effort input as possible.

Rather than use lab-based tests employing plexiglass enclosures and a confined mouse population, I chose to use natural free-ranging mice as in test designs previously used to test efficacy of sound devices against the Norway rat *Rattus norvegicus* (Ashton 1999). I feel such real world

tests on free populations produce far more valid results than artificial enclosure studies, based on my 35 years of experience doing research in natural settings as a PhD in ethology. Equipment efficacy is best tested in the natural environment for any species, for normal responses to novel stimuli are far more likely to be witnessed in such settings than in unfamiliar surroundings. This principle of testing in natural settings has also been strongly advocated for in print (Beck and Stein 1979) expressly as a means of obtaining the most valid results of new equipment to be tested in repelling vertebrate pests.

The necessary first step to establish efficacy of sound based pest repeller equipment is to design tests that help to establish that the species to be studied can perceive and does show response to the auditory signals generated by the equipment to be tested. Lacking references for details of specific frequency ranges perceived by, and relative auditory acuity of, white-footed deer mice, (*Peromyscus maniculatus*), I relied on an indirect assessment of sound detection. I hypothesized that repeated observation of altered behavior or avoidance of normally used areas by individuals of *P. maniculatus* when exposed to sounds produced by the Transonic Pro sound generating unit (hereafter T-PRO) Bird-X Inc., Chicago, IL, would constitute evidence that they perceived and responded with avoidance to such sounds. I set my data collection design to determine whether the sounds generated by these devices do or do not alter behavior/presence of mice in a measurable, repeatable fashion and whether they demonstrated efficacy in repelling mice from homes.

RESEARCH SITE

The research site used for these tests of the ultrasound equipment efficacy in reducing mouse presence and droppings evidence was an old farm house in Marquette County, Shields Township section 6, T16 N-R10E in central Wisconsin. It was constructed in stages with central rooms dating to 1870 and addition of two extra bedrooms over a crawl space north of the living room and original foundation, and a second floor with four more bedrooms added between 1920 and 1925. Final additions of an indoor bathroom and a back hall that provided access to a new stairwell leading to the original fieldstone-walled basement (root cellar) were constructed in 1964. The piece-meal nature of the construction and age of materials make the house highly porous to the invasion of mice, at least to the kitchen and living room areas derived from the original two room log cabin portion of the house. It has been the weekend recreation residence of my family for 63 years. As a career biologist, I have kept marginally complete 35 year records of small mammals caught or killed there.

Of over 500 dead mice recorded from the house during that time; in snap traps, live traps, glue pads, and drowned in antifreeze in winter toilets or pump drain water in buckets in the basement, only two have been the house mouse (*Mus musculus*), from Europe. All remaining mice were the native white-footed deer mouse. Among the highest recorded two day (generally weekend time frame) totals were seven deer mice trapped in 48 hours December 26 and 27, 1996 (Whitford 1997). Reproduction in this species continues as long as the mice are warm and Central Wisconsin litters were reported to average 4.77 per pregnancy (Long 1973). Local mouse numbers vary seasonally and year to year, based on changes in natural food abundance, habitat, and weather. My records indicated mice generally began entering the house in numbers in late August or early September, and numbers trapped peaked in November or December, as they searched out winter homes. They continued to move into the house in declining numbers until April, when catch rates fell to yearly lows. Suffice it to say that mouse droppings and visual sightings (and continual trapping) were a normal part of life in this house since I first arrived there in 1955.

METHODS

The ultrasonic/sonic pest repeller unit tested was a single T-PRO. It was used only on "quiet" volume setting and sound pattern "C" (mice setting), for all tests and produces a frequency range of 20 kHz-45 kHz at 72 - 78 dB @ 0.5 m on this setting. Efficacy was assessed using indirect evidence of ultrasound detection and/or avoidance by mice based on absence or major reduction of mice trapped or droppings counted on kitchen counters when the unit was producing ultrasounds. In all study cycles, six Victor brand snap traps baited with peanut butter were kept on the top three stairs (two per step) leading from the basement into the 2.5 m × 1.1 m entrance hall from our exterior back door to a second inner hall door, kept continuously closed, but with a 1-cm gap under it that mice were known to use to enter the kitchen area. Tests compared two partial-year paired tests and four full-year

paired test years using mice trapped/droppings counted in the kitchen per test period with T-PRO repeller "ON" vs "OFF." Specific tests cycles used one T-PRO in the back hall, dates 2 Aug. - 5 Dec. "ON" in 2009 and "OFF" for the same dates in 2010. Repeat tests were done with T-PRO sound "ON" continuously 25 Nov. 2012 to 25 Nov. 2013, and "ON" again 25 Nov. 2013 to 25 Nov. 2014. Two additional year "control tests" used the T-PRO turned "OFF" 1 May 2015 to 1 May 2016, and 1 May 2016 to 1 May 2017. Exact pairing of test cycle dates and use of multiple year test cycles were done to reduce possible influences of variation in seasonal and or annual wild mouse populations near the farm house that might have impacted test results.

Mice were presumed to regularly enter the house along old decaying wooden foundations laid atop a short irregular stone base beneath the two main rooms of the house. Lack of significant mouse problems in downstairs or upstairs bedrooms suggested most mice moved into the main house by entering the basement and then climbing the basement stairs and entering the kitchen through the back hall. Based on this assumption, I placed the T-Pro unit against the inner door in the back hall with the speakers facing the wall directly across the hall. This forced mice to pass within less than 1 meter of the ultrasound generated to gain entry to the main house, so they would receive a sound pressure of 74 -78 dB with minimum attenuation. I made my data collection design as free of confounding error sources as possible and kept data collection as simple as I could so personal observed bias would have no opportunity to influence the results. I used the same sound equipment in the same location over all six test cycles, only turning it "OFF" or "ON" for new cycles of data collection. My only means of evaluating efficacy were direct comparisons of number of mice trapped and numbers of droppings counted in the kitchen with units turned "OFF" versus "ON." I recorded dead mice on a clipboard hung on the exterior doorknob before removing the mouse/mice from traps and rebaiting traps. I recorded direct counts of droppings from the kitchen immediately upon first entering the house and before checking for dead mice. This house is on a recreational farm some distance from my main home, but I get there weekly most of the year.

The ultrasound unit was always set on "quiet" setting which used only sounds produced above 20 kHz, at 88 - 98 dB at the speaker, and roughly 78 dB @ .5 m from the speaker. The sound unit was placed on a linoleum floor facing the opposite wall of the hallway and 2.4 meters from the top of the stairs. Traps were placed two on the lateral margins of each of the top three stairs. The nearest trap was 2.1 meters right of the sound unit and 1-1.6 meters away from the wall the sound unit was resting against depending upon which step the trap was placed on. As was usual for the house in all the years I've known it, paper bags for garbage and for recycling materials were present between the stove and counter/cabinet end on the kitchen floor, and left there until full before being removed for disposal. All floors, counters, stairs and basement areas were thoroughly vacuumed before data collection was begun for each test cycle to remove all visible mouse evidence. Lack of evidence of droppings and absence of

mice in traps was considered to be valid indirect evidence of sensitivity by the mice to the sound frequency broadcast by the T-pro sound unit tested and to represent documentable, reproducible changes in behavior in response to those sounds being broadcast. Thus, all the above were considered to be indicative of efficacy of the units in reducing mouse presence and/or damage.

RESULTS

No mice were trapped or droppings observed for four months in 2009 versus 32 mice trapped in the house and 67 droppings collected on the counter for the same time period in 2010 – an average of eight mice trapped and 16.75 droppings found per month. In the 12 month test 2012-2013 with the sound unit “ON,” six mice were trapped and only three droppings found on the counter on a single occasion – an average of 0.5 mice trapped/month, and 0.25 droppings/month observed. For the full year test 25 November 2013 to 25 Nov. 2014, again with the sound “ON,” 5 mice were trapped and 11 droppings counted. For the final two “control” repeat counts 1 May 2015 to 1 May 2016 and 1 May 2016 to 1 May 2017, the T-PRO unit was present but “OFF,” and 26 mice were caught and 54 droppings counted, and 33 mice caught and 43 droppings counted for these years, respectively.

A null hypothesis unpaired two-tailed T-test indicated P value = 0.0007, T = 92998, df = 4, mean 30.33 for mice caught/test cycle with the sound unit “OFF,” versus 3.67 caught per test cycle with the sound unit “ON.” A similar T-test for droppings counted had a P = 0.0150, T = 5.0506, df = 3. Using the combination of snap traps and the T-PRO ultrasonic sounds it generated as a form of integrated pest management, there was no damage done to food stuffs in cabinets and cupboards during test cycles when the sound units were “ON,” and 91.5% fewer mouse droppings to clean up and 86.7% fewer mice to remove from traps, than when the unit was turned “OFF.”

DISCUSSION

Contrary to prior reports of lack of demonstrated efficacy, or only partial efficacy of ultrasound units to repel rodents (Munro and Meeham 1987, Bomford and O'Brien 1990), the results for the tests with the Transonic PRO ultrasound unit were unequivocal and strongly indicated audibility to the mice and a high level of efficacy at repelling them such that it significantly reduced evidence of mouse presence in the house. Those prior studies also indicated that ultrasounds were highly directional, and rapidly attenuated over short distances or when penetrating soft surfaces, such as cardboard, and prone to failing to be audible in sound shadows created by solid objects in the line of the ultrasound produced. However, Ballard et al. (1984) reported that plywood which normally absorbed and diminished ultrasound energy, would show minimal sound loss and maximize sound reflection if painted with two coats of enamel paint. Since I painted it myself at least three times since 1976, I know the back hallway of the farm house had at least six coats of enamel paint over the wooden baseboards, gypsum wall board of its walls and ceiling, and the wooden faces of the doors at each end of the hall. Layers of enamel paint on all these surfaces apparently reflected

the ultrasound of the T-PRO from wall to wall and off the doors at each end of the hall and down into the upper reaches of the basement step area, which should have been a “sound shadow area” where the ultrasonic sounds would be absent according to most past authors of failed tests of ultrasound pest devices. With regard to ultrasound, Krasilnikov (1963) wrote “maximizing sound reflection in a closed cube (or small room-my interpretation) would result in a mixed or diffused sound where every point in the cube would have approximately equal sound.” This would explain why in my test results when the T-PRO was producing ultra sounds at 78-98 dB, very few mice came far enough up the stairs to reach the peanut butter on the baited traps and get caught. When the ultrasound was “OFF” they came farther up the stairs and got caught in the traps there. That indicated the sound was preventing them from approaching the top of the steps when it was on, and that the sound was audible even in the theoretical “sound shadow” at a minimum indirect distance of 3.5 m from the sound source. Placement of the T-PRO unit, where mice had to pass it to enter the kitchen and other main areas of the house, may have initially been fortuitous, in that it exposed the mice to the greatest sound pressure level for the frequencies used. However, it also appeared, based on paucity of visible evidence of mice, to greatly reduce mice use of the stairs, the hallway, bathroom and living room, or roughly 540 sq ft of the house, so that precise placement of the unit may not have been the sole issue in its success.

There is little question that any prior research on the use of ultrasound to repel mice which concluded it to be “ineffectual or only partially effective” was incorrect in those conclusions based on the unambiguous results in this study. The most logical explanation for why prior studies might have failed to find ultrasound effective is that “ultrasound” as a name defines an extremely large range of sounds above normal human hearing frequency, from 21 kHz to well over 140 kHz. Thus, use of incorrect ranges of ultrasound frequencies to attempt to repel mice in past research would mean that the species studied might not have been able to hear the sounds. The sound pressure level at which the ultrasound is produced by the ultrasonic pest control device is also extremely important to success of the device in repelling mice, and many of the early device tests produced less than 75 dB at the speaker, too little to deter rodents, apparently. Tests by Ballard et al. (1984) used ultrasound devices generating sounds above 20 kHz at sound pressure levels of 54 dB or less, and 30 dB for sounds at 42.5 kHz. Since the decibel sound pressure scale is a log 10 scale, these sound pressures were more than 1,000 and 10,000 times less loud than the 90 dB of the T-PRO. The T-PRO has an effective sound range of 20-30 feet from the speaker, so these other units would be expected to evidence effective ranges of less than 1 m at the lower dB levels they produced. A second confounding variable in any such study is that very high frequency sounds have extremely short wave lengths and very little energy, and thus dissipate rapidly in air, and even more rapidly in cardboard, such that 0.3 cm of corrugated cardboard reduces ultrasound amplitude by more than 70% (Gold et al. 1984), making it almost inaudible to an animal hiding behind a sheet of cardboard. Tests conducted to determine perception or response at distances

beyond several meters might have failed simply due to attenuation/absorption of much of the high frequency sound spectrum by the surrounding air and sound environment. Finally, one might mention that tests conducted in an unnatural setting might see little change in behavior of an animal that is already agitated by the unfamiliar environment it finds itself in and proximity of researchers. Animals tested in such a foreign environment might rapidly habituate to the test sounds if they could not get out of hearing range of it, especially if no adverse effects occurred over an extended time of exposure to that sound. Despite the fact that dogs are known to hear into the low end of the ultrasound range (think silent dog whistles), and show aversive responses to some ultrasound frequencies (Blackshaw et al. 1990) there was no evidence observed in this study that the sounds generated by the Transonic PRO as it was used, were audible or distressing to dogs. Both a 7-year-old golden retriever and a 9-year-old black lab were regular visitors to the house used for the tests and never showed signs of perception of, interest in, or avoidance of the sound generating unit when it was on.

This study reports results of first multiple year long tests of an ultrasonic pest repelling device used in a natural environment where the mice were free to leave the area entirely in response to the sounds broadcast. Test evidence suggests strongly that they did just that in most cases and failed to habituate to the sounds as a result. Efficacy of the units at reducing mouse evidence and mice trapped was approximately 90% across all three test cycles when the sound unit was on and coupled with snap traps as an integrated pest management system, as compared to the three cycles when the ultrasound was off and mouse catch rates were very high.

It is evident that ultrasonic frequencies produced by the T-PRO units tested in this study are audible to wild white-footed deer mice (and cause them to avoid proximity of such sounds). Repeated years of tests demonstrated the efficacy of the T-PRO unit in discouraging mice from using the areas where the sound units were on, and almost completely eliminated need to clean mouse droppings from kitchen counters or to bait, set, or empty mouse traps, or to worry about use of poisons in homes with pets or small children. With proper placement and numbers of sound units for the areas to be protected, the units provide an extremely easy, inexpensive means to reduce mouse problems. There was no evidence that the mice habituated to the ultrasonic sounds. Slight increase in mouse numbers trapped in the final year of the study may indicate that the sound units suffer some decay in frequency or sound pressure with long term continued use. It may help maintain maximum efficacy if units are replaced after two years of use. Whenever possible, I would advocate putting the sound unit on the floor with the speaker near and aimed toward any suspected point of entry into the home, the kitchen, or food service area, for maximum efficacy in reducing/preventing rodent entry and damage.

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