Roof rat invasion of an urban desert island

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Abstract. Roof rats have invaded the Phoenix metropolitan area. Although the desert surrounding Phoenix is formidable to roof rats, residential and urban development has probably sufficiently altered habitat to render it suitable for roof rats. Ongoing community and government campaigns are reducing the resources necessary for rat survival and are working to suppress rat populations. Whether these efforts will be adequate to eradicate roof rats from the area is unknown. Rat activity has declined over the past several months. However, it is difficult to assess whether this reduced activity reflects decreased rat numbers or if rats have become less active during the summer heat.

Introduction

Roof rats (*Rattus rattus*) first arrived in the contiguous United States on sailing vessels along with early explorers and colonists (Lowery 1974). Their distribution had expanded considerably along routes of commerce by the late 1700s (Jackson 1982). Subsequently, roof rat distribution declined, particularly from northern and inland areas, as their populations were gradually displaced by Norway rats (*Rattus norvegicus*) (Jackson 1982). The current distribution of roof rats within the continental United States is along the lower half of the East Coast, throughout the Gulf States, and along the Pacific Coast. States located within the interior of the United States are generally free of roof rats. However, infested cargo may produce isolated infestations (Marsh 1994).

Roof rats have appeared sporadically in Arizona. The first known roof rat in Arizona occurred during 1890 with dual invasions of Tucson and along the Colorado River near Yuma (Cockrum 1960). Two years later, roof rats were reported in Cochise County (Hoffmeister and Goodpaster 1954). Roof rats did not appear again until a series of small invasions during 1900 in Yuma and Tucson and towns located in the San Pedro and Santa Cruz valleys, and then a brief emergence near Miami during 1922 (Cockrum 1960). They did not persist after these initial invasions. Their failure to establish is most likely attributable to poor habitat—specifically, sparse availability of desirable vegetation and limited water resources. Cockrum (1960) reported Arizona to be roof rat free in his book on Arizona mammals. However, an increasing human population and associated urban and residential development is changing the Arizona landscape. Introduced plants and increasing irrigation are probably leading to an increase in rat habitat. During the 1970s, an outbreak of roof rats occurred in the warehouse district of Globe, Arizona. An eradication program implemented by local authorities continued for 3 years before Globe was claimed to be roof rat free (Hoffmeister 1986).

In early December 2001, a resident notified the Maricopa County Environmental Services Department that he had seen a rat outside his home in Phoenix, Arizona. The Department's Vector Control Program responded by placing live-traps in the vicinity of the resident's home. Shortly thereafter, a rat that had been electrocuted while crossing a power-line in the same neighborhood was positively identified as a roof rat. Subsequently, a live roof rat was captured on 19 December 2001. Expanded rat trapping and neighbourhood reports suggested roof rats occupied approximately 15 km^2 by early January 2002. This area was expanded to include 41 km^2 a couple of weeks later.

The objective of this paper is to describe why the current rat infestation may be more problematic than those occurring before it, initial reactions to the infestation, and preliminary results of control measures.

Rat infestation of Phoenix

Human emigration into Arizona has significantly altered resource availability over the past few centuries, often expanding suitable roof rat habitat. Early rat populations probably faded because necessary resources were sparse. Several changing environmental attributes in the Phoenix

metropolitan area may be enhancing the potential for current invading rats to establish successfully. Water is probably no longer a limiting factor across most residential and agricultural areas of Arizona. For example, irrigation channels and ditches, flood irrigation of crops and lawns, drip irrigation of flowerbeds, sewers, leaking faucets, and pet dishes—among other avenues—provide excellent water sources for rats.

Plant communities also have been significantly altered. Roof rat distribution has been correlated with introduced plants. Rat populations on the west coast have expanded considerably because rats have utilised blackberry (*Ribes* spp.) associated with old mining camps (Jameson and Peeters 1988), and the lush vegetation planted along freeways and urban housing developments (Jackson 1982). Exotic plants were first introduced to the Sonoran Desert by the Spanish in 1540 when wheat and other crop seeds were distributed to Native Americans (Tellman 2002). Today, many plants introduced for landscaping or agricultural production provide at least adequate, if not excellent, food and cover for roof rats. At present, an estimated 233 non-native plant species contribute to the flora composition (Wilson et al. 2002). Introduced ornamentals used for landscaping further contribute to a changing plant community. Citrus and nut trees in yards, and interlocking hedges and vines draping over fences are common within the residential neighbourhoods most recently infested by roof rats. Other sources of rat food commonly found include poorly stored food, pet food and garbage. These readily available food sources combined with improved cover and water greatly increase the potential for the new invaders to become established as compared to opportunities afforded rats during prior invasions.

Altered fauna populations also may benefit roof rat establishment. Natural predators and species normally competitive with roof rats may be less abundant. Snakes have been largely displaced, or populations suppressed, in urban neighbourhoods (Rosen and Schwalbe 2002). Domestic cats have contributed to the disappearance of many wildlife species, including competitive rat species (Rosen and Schwalbe 2002). Roof rats do not compete well with Norway rats (Jackson 1982), and most likely do not compete well with wood rats (*Neotoma* spp.). Roof rats may fare better where populations of these species are sparse. The arboreal nature of roof rats may make them less vulnerable to cats and other urban predators than some other rat species.

Potential problems inflicted by roof rats also have increased as the Sonoran Desert has been developed. Foraging roof rats can inflict significant negative impact on citrus and nut crops (Marsh 1994). Acreage devoted to citrus and nut production in Arizona continues to increase. Mean annual production over the past five years is valued at nearly US$150 million. If roof rats became established within these orchards, subsequent consequences could be devastating to these industries. Another potential problem is contamination of stored feeds or animal facilities. Rats living in attics, walls, and basements commonly gnaw on electrical wiring, causing communication and power disruptions. Exposed and frayed wires then pose threats for electric shock or fire (Cogelia et al. 1976). Rats also serve as vectors and reservoirs for diseases communicable to humans (Chin 2000). Therefore, public health is always a concern when rat infestations occur in residential neighbourhoods.

Initial response

Successful urban rodent control needs to focus on long-term strategic, comprehensive approaches that incorporate multiple tactics and partnerships among government agencies, community groups and pest control companies (Colvin and Jackson 1999). Whenever possible, such control programs should focus on altering habitat and reducing its potential for attracting and supporting pest species. Otherwise, benefits derived from control measures will be short-lived and frequently repeated (Davis 1972).

Government agencies, primarily county, began formulating a response plan soon after officials suspected a potential roof rat infestation. The first response to the rat sighting was to identify the species. Once roof rats were confirmed, efforts were initiated to confirm boundaries of the area infested by rats. This area quickly expanded from 15 km^2 to 41 km^2, centered on the Arcadia–Camelback Mountain area of Phoenix. Whether this expansion reflected increased rat dispersal or merely better surveys is unknown. A contingency plan addressing an influx of roof rats to the Phoenix area did not exist. In retrospect a plan would have been beneficial.

The Maricopa County Vector Control Office sponsored a series of meetings during January 2002 to gather agency support, share information, and begin developing a response plan. A wide spectrum of interested groups and agencies were represented at these meetings. Subsequently, Maricopa County assumed a lead role in developing and implementing a plan to address real and perceived problems caused by roof rats.

Maricopa County issued a news release that urged citizens to cover trash containers, use rat-proof containers to store food items, eliminate rat access to pet foods, pick up fallen citrus, and harvest fruits remaining on trees. The release also announced an upcoming public meeting scheduled to explain the situation and to address public questions. At the meeting, hundreds of local residents were provided an overview of roof rat ecology and management, and advised to clean up yards, remove citrus fruits from their property, and to use traps or baits to manage local rat populations. Residents also were told that the City of Phoenix would haul away unwanted citrus and assist in organising campaigns to clean up public and common-ground areas.

Direct measures to combat roof rats were implemented by mid-February 2002. More than two-dozen groups participated in the rat eradication effort. The City of Phoenix provided bulk trash bins for residents. The Arizona Department of Health Services, in cooperation

with Maricopa County Environmental Services, began testing roof rats for hantavirus, bubonic plague, and tularemia. Food banks and family assistance programs accepted undamaged discarded citrus from clean-up campaigns. Several neighbourhood groups were organised to clean common areas or assist those residents less capable of picking fruits or cleaning debris from their properties. Personal-use bait stations and snap-traps were distributed by county and volunteer groups until supplies were depleted. Home-owner associations sold additional bait stations at the cost of materials. Educational programs continued, ranging from leaflets to group meetings, urging residents to take necessary steps to deny rat access to cover and food.

Maricopa County Vector Control implemented a baiting program to suppress and hopefully eliminate rat populations. Their target area, including a buffer zone, was approximately 60 km^2. Certified County employees, assisted by volunteer apprentices, affixed approximately 6000 bait stations 2–2.5 m above the ground on utility poles. Utility poles were spaced 30–60 m apart and were located primarily along alleys. Stations were initially installed in areas considered 'hot spots' and in the 0.75 km buffer zone established along the outside perimeter of the infested area. Bait stations were constructed of polyvinyl chloride (PVC) pipe (30 cm long and 10 cm diameter) capped on both ends, and a hole drilled in the middle to permit rat access, but minimise non-target exposure. Each station was treated with 225 g of bait containing 0.005% bromadiolone. The Vector Control group monitored stations at least once a month, replacing any bait that had been removed.

Preliminary results and discussion

An integrated plan was developed to eradicate, or at least abate, roof rat establishment in the Phoenix area. Numerous community groups banded together to remove potential rat food and rat habitat. One optimistic volunteer considered the "rats a blessing, not a curse, in that they have brought us closer as a community...and are pushing us in a direction we need to go, and that's cleaning up our properties." The 'NEIGHBOR to NEIGHBOR' campaign picked, and donated to food banks, approximately 31.5 t of citrus through their efforts to rid neighbourhoods of rat food. Their future goal is to collect and donate more than 750 t of citrus next season. Resident and volunteer groups deposited almost another 100 t of waste citrus and debris in dumpsters distributed and serviced by the city. These efforts have greatly decreased availability of food and cover for rats. Unfortunately, some residents have not participated in the clean-up campaign, leaving pockets of citrus and other desirable rat habitat attributes. It is unknown whether these havens will enable rats to establish and disperse throughout the community in the future. Community organisations also have worked with residents to set bait stations and traps on private land inaccessible to county officials.

City, county, state, and federal governmental agencies have all contributed to roof rat eradication. Public awareness programs have greatly enhanced public involvement in rat proofing their homes, installing traps and bait stations on private land, and monitoring for rat activity. The Arizona Department of Health Services has tested rats and has thus far not found evidence of disease communicable to humans. Maricopa County Vector Control has taken the lead role to suppress roof rat populations. Over 1 t of bait has been distributed through approximately 6100 bait stations mounted on the utility poles. Few stations (less than 0.5%) have been vandalised or otherwise damaged. Vector Control also has set rat traps in areas believed to contain high rat populations or where bait stations may pose perceived problems. Other agencies have enhanced control efforts by contributing funds, labour, equipment, and expertise.

The efficacy of these programs to eradicate roof rats is largely unknown. Rat activity appears to have declined, according to indicators such as bait disappearance, trapped rats, and residential calls to hotlines. Whether this reduced activity means suppressed populations or merely reflects less movement by rats during the higher summer temperatures is difficult to ascertain. A more accurate measure of program success will occur next winter, when temperatures drop and citrus trees bloom and begin producing fruit.

Conclusions

Roof rats and other rodents have been introduced to new localities throughout the world. Invading roof rats have established and wreaked havoc on many island ecosystems (Atkinson 1989). Urban and residential development may be creating islands of habitat suitable for roof rat survival. While ships were required to transport invasive species among islands, their movement across inhospitable terrestrial sites should be relatively easy, given the rapid transport of goods and constant movement of vehicles. Therefore, municipalities may need to consider whether development is creating habitat for invasive species and the likelihood these species will be introduced. If conditions favour a species capable of causing devastating impacts to a region, then contingency plans may need to be considered. Under some conditions, it may be reasonable to establish monitoring programs for early detection, e.g. a monitoring program for early detection of roof rats in Arizona citrus orchards. However, it is understandable why government agencies are hesitant to extend limited resources to address concerns with species supposedly non-indigenous to their locality.

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